AMERICAN SOCIETY OF CIVIL ENGINEERS.

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313.

(Vol. XIV.—October, 1885.)

NEW METHOD OF MAKING CONVENTIONAL SIGNS ON ORIGINAL TOPOGRAPHICAL MAPS.

By J. A. OCKERSON, M. Am. Soc. C. E.

READ AT THE ANNUAL CONVENTION, JUNE 26TH, 1885.

The use of characters, rather than colors, to represent on maps the different kinds of vegetation, soil, etc., has mainly been restricted to maps issued by the General Government. The principal reasons for this have doubtless been that the former, being hand work, was too expensive, and required too much time for general use; and, furthermore, draughtsmen skilled in this class of work are quite rare. No system of colors can give as satisfactory a representation of the surface features of the section mapped as can be obtained by a proper use of conventional characters.

If it is desired to reproduce the originals by photo-lithography or analogous processes, the latter style is far more economical.

For making these characters mechanically, stamps of different kinds have been devised, but I believe that heretofore their use has not been successful, owing to the difficulty of producing characters of the required excellence, and also to difficulties of manipulation of the stamps.

In a series of maps it is desirable to have a uniform style throughout; and where the number is large, so as to necessitate the employment of several draughtsmen, this can only be accomplished by assigning a particular class of work to each man, and have each chart pass through several hands. This may be very trying to the individual, as some of the work, such as sanding, is very tedious and monotonous. On the whole, the plan serves to improve the quality of the work, but it is not calculated to increase the caliber of the employees, and should, therefore, be avoided if possible.

The recently completed topographic and hydrographic survey of the Mississippi River, from Cairo to Donaldsonville, covering some 2 800 square miles, made chiefly under the direction of the Mississippi River Commission, is projected on some 230 antiquarian (31″ x 52″) sheets. As it was very desirable to have the data available at the earliest time possible, I began experimenting with different devices for printing conventional signs as well as letters, bearing in mind that the results must be as good, or better, in quality than the usual hand work on similar maps, and that simplicity and speed were essential elements. The Secretary of the Mississippi River Commission, First Lieut. Smith S. Leach, Corps of Engineers, M. Am. Soc. C. E., gave me every facility for carrying on these experiments, and the results, I believe, are of sufficient importance to justify a description of the several steps which culminated in a mechanical device for printing conventional signs on original maps that has been found satisfactory in the work described above.

The first thing necessary was to find some way to construct suitable characters of metal or other hard material. Engraving was tried, but with indifferent results. Drawings one inch square were then made of two signs, cotton and woods, and the photo-electrotyping process was tried. In this way the signs were produced in type-metal and they were mounted like the rubber stamp in common use. The result was by no means satisfactory, as the individual signs did not stand out enough, and, when inked by hand, the stamp would clog up. The signs were good, and when used in a printing press, the impression was found to be a fac simile of the original drawing, with the fine lines all faithfully reproduced. Another trial was then made with a drawing four inches square, and a special effort was made to etch as deep as possible. This was found quite satisfactory, as far as the signs were concerned, but it required too much pressure to admit of use by hand. To obviate this,

rubber stamps were cast from the metal ones, and with them it was found that a single impression could be made very well, but the adjoining one, in consequence of variations in quantity of ink or pressure, would not be the same shade. Then there was also the difficulty of joining the different impressions when the area required was larger than the stamp. For areas smaller than the stamp, a stencil of the size and shape of the field to be printed was cut from thin paper, and the impression was fairly good. On the whole, a sheet of paper printed over in this way had a pattern-like appearance, due to the difference in the impressions and also to the repetitions of the forms given by the stamp. The flat-metal stamp could not be used in printing through a stencil, and the rubber could not be relied on, so a cylinder was resorted to, the idea being that, as there would only be one line in contact with the paper at a time, sufficient pressure could easily be applied. The cylinder was solid cast-iron, 4¼ inches diameter by 6 inches long, and weighed about 27 pounds. An electrotype of the signs was made into a hollow cylinder of a size that would just slip over the iron one. The latter was provided with ink rollers on a suitable frame, by means of which the stamp was inked as it was rolled over the paper. The metal for this stamp was about ⅛-inch thick, and, in bending it into a hollow cylinder, it was impossible to keep the surface straight. The ends would expand more than the center, hence the latter diameter would be smaller, and would, consequently, give a very light, if any, impression, while that at the ends would be heavy. The surface was too delicate to admit of hammering, so, after several attempts to remedy the defect, it was given up, and rubber was again resorted to. Rubber stamps were cast about ⅛-inch thick and these were used on wooden cylinders of the same dimensions as the iron one and used in the same frame. With this arrangement an effort was made to obtain uniformity in the impression by using a constant weight, but without success.

So far the stamps themselves were all that could be desired, and the cylinder seemed to be the proper form for them, but they could not be manipulated so as to give the required results. It was evident by this time that a uniform impression all over the map could only be obtained by using a stamp with a hard surface, and it should also be elastic so as to print through a stencil.

A copper electrotype shell, *s s*, Fig. I, Plate XXVI, was then made, and backed with rubber, *r r*, Fig. I, about ⅛-inch thick. This was

wrapped around a wooden cylinder, *w w*, Fig. I, of the same diameter as the former ones, but only 3 inches long. An adjustable handle, *h h*, Fig. I, passing through the axis, giving it the appearance of a rolling-pin, completed the device. This is inked for each revolution by revolving it in contact with an ink-roller, Fig. II. In printing, it is rolled slowly over the map, the amount of pressure being regulated by the force applied at the handles. It will be seen that the full size of one revolution of the roller will be about 3 inches by 13 inches, but many of the areas, such as fields, etc., are much larger than this, and as the joining of two impressions is easy to make by laying a piece of paper along the printed edge and letting the roller overlap a little, it was not thought best to increase the length of the cylinder, as it would require more pressure.

This device was found to work perfectly through stencils of any size and shape.

There still remained one difficulty in the way of rapid execution. The outlines of the map, such as water courses, roads, etc., as well as the lettering, are necessarily put on the map before the signs. To print the signs and not interfere with these characters, which should remain clear and distinct, was quite essential. After trying several plans, such as covering with narrow slips of paper, etc., a pencil made of common starch was finally hit upon. This proved to be entirely satisfactory. To cover up a name, it is only necessary to pass the pencil over it once and the ink on the stamp will not take on the starched surface. After the printing is done the starch can be whipped off, leaving the name as clear as though it had never been touched.

The various conventional signs required by the characteristics of the country mapped, viz., woods, willows, grass, cultivated, cotton, sugar-cane, sand, etc., are now in daily use as above described. Before printing the chart, stencils are prepared for the whole sheet. Any thin, transparent paper will answer for this purpose. An ordinary antiquarian sheet, covering about 900 square inches, can be prepared and printed in two days. The same work would employ a skillful draughtsman at least a month.

Sand bars, which are so tedious when made by hand, one dot at a time, can be printed to perfection with the exception of the shading at the edge, which must be done by hand. Sanding, such as is used on hydrographic charts to show different depths, can be done with an absolute

PLATE XXVI.
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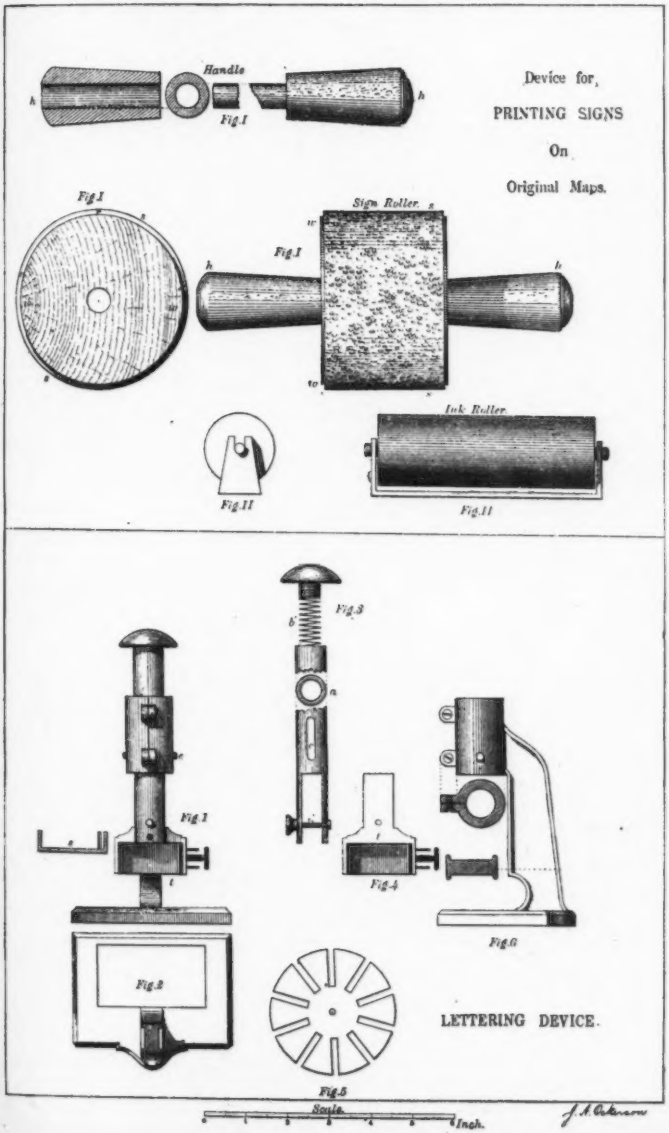

certainty that the tints will be the same throughout for each depth represented.

For maps that are to be reproduced by photo-lithography, it is best to make the original large enough to admit of reduction to one-half the scale. If it is desired to publish on the same scale, the printing can be done with lithographic transfer ink, and a transfer made to stone or zinc, from which any number of copies can be printed. In this case the outlining should be done on suitable transfer paper with autographic ink, and the names printed with transfer ink. Transfer this to the stone or zinc, and from this take a faint impression, called an "offset," and on the latter print the signs with lithographic ink. When this is done, transfer to the same plate that bears the outlines, and it is ready for the press, and any number of copies can be struck off.

In using the stamps described above, it is desirable to work on paper with a smooth, hard, and highly calendered surface, so that the impression will be clear and sharp. The best ink is the finest quality of "German Printing Ink."

Plate XXVII is a small portion of a map on which all of the conventional signs, letters and figures were printed with the devices described in this paper. It has been reduced by photography to half the scale of the original, and as a result of the reproduction, has suffered somewhat in sharpness of detail, but it still gives a fair idea of the possibilities of mechanical mapping.

It will be readily seen that any character desired can be made and used in the manner described. Having the original drawing from which to produce the stamp, the work of the best draughtsman can be multiplied without limit, and not detract very much from the quality or style of the original. There are, of course, very fine grades of work, such as are used on small scale maps, which can only be done by hand. But for ordinary work the results are entirely satisfactory, both as to quality and cost.

Plate XXVI shows the apparatus, which needs no further description. Fig. I is the roller, with the handles in, ready for use, and showing the electrotype shell *s s*, and the rubber backing *r r*. Fig. II is the ink-roller, made of common roller composition.

A stamp for putting on letters and figures is also shown, it being a valuable adjunct to the device described above.

Fig. 1, Plate XXVI, shows one bearing a type-holder, also shown

separately in Fig. 4. A set of figure disks is shown at Fig. 5. These two parts are interchangeable and can be used in the same stamp, and are only separated to show how they are attached.

Common type of suitable size and style are used. For names, etc., words are "set-up" in the typeholder and held by the clamp-screw *d*.

The base of the frame being at right angles to the line of the type in the holder, the names can always be printed parallel to the sides of the map by sliding the frame along a ruler. With a little practice this can be done with sufficient accuracy by inspection.

Where the same word is repeated frequently on the map, the time saved is very considerable, while the quality of the work is good.

For figures, such as soundings, three disks are used, each of which bears the ten digits. They revolve freely on an axis, and with them any combination from 0 to 999 can be formed. These figures are also common type, which are held in place by fitting snugly into the slots cut for them. When they become worn they can easily be replaced by new ones. With this device soundings are printed neatly and rapidly.

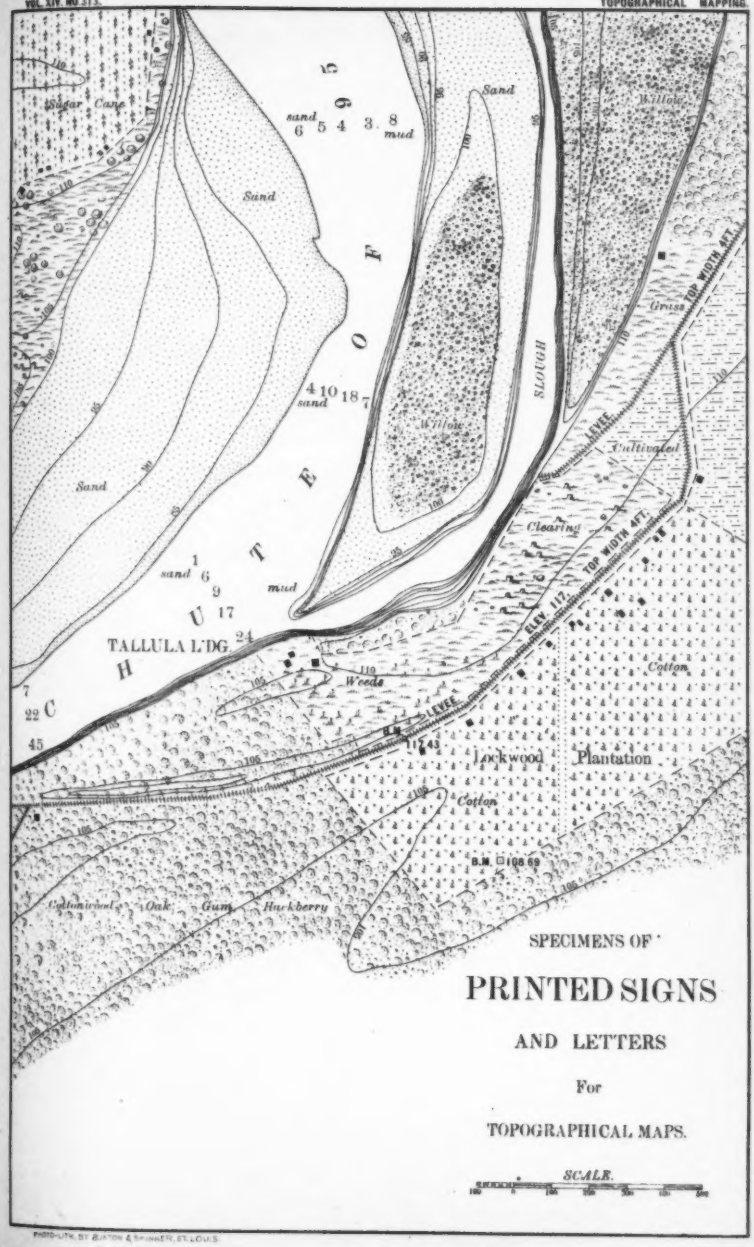

PHOTO-LITH. ST. BARTON & SCHMIDT, ST. LOUIS.

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(Vol. XIV.—October, 1885.)

POWER BRAKES FOR FREIGHT TRAINS.

By WILLIAM P. SHINN, M. Am. Soc. C. E.

READ AT THE ANNUAL CONVENTION, JUNE 26TH, 1885.

In my paper on "The Increased Efficiency of Railways for the Transportation of Freight," read before the Society December 20th, 1882,* I stated that among the improvements wanted was "a good train brake for freight trains, as nearly automatic as possible in its action. Such a brake, combined with automatic block signals, would make a rear collision absolutely indefensible and almost impossible." The subject of power brakes for freight trains has received far more attention from inventors than it has from the managers of our railway systems. The records of the Patent Office show over six hundred patents for brakes applicable to railway engines and cars, and there are some ten or twelve parties claiming to have complete systems of freight-car brakes, while at this time the number of freight cars equipped with power brakes is not probably in excess of four per cent. of the whole number of freight cars in the United States. The Master Car Builders' Association appointed at its

* Transactions, Vol. XI, November, 1882, page 385.

meeting in 1884, a committee of three to report on this subject. The committee, at the meeting held at Old Point Comfort, in June, 1885, made the following report:

Report on Automatic Freight-Car Brakes.

To the Master Car Builders' Association:

In submitting a formal report on the above subject, we feel some hesitation, owing to the importance of the question and a conviction of the superficialness of our investigation; this conviction, in place of diminishing as different brakes were examined, only seemed to increase. A complete report on Automatic Freight Car Brakes should be accompanied by an elaborate and thorough series of comparative trials and tests, which, it is hardly necessary to say, was quite beyond the limited field of the Committee, nor will such investigation be accomplished until a more general interest is taken in the different forms of brakes by your respective companies.

In considering this subject, your Committee first proposed confining their attention to such brakes as the lines represented in the Association had adopted or successfully experimented with, and with this intent issued a circular of inquiry to each member. From the replies received the question seems to have had very limited attention, and your Committee were in some cases obliged to pursue their investigations through sources and courtesies of companies on which they had no claims whatever.

It may be well to state here that the brakes named later in our report have not in any sense been selected on account of specially recognized merit; they are mentioned simply because your Committee have seen each on cars in actual service, and we hope by directing attention to certain features of one which may be wanting in the other, to aid our members in determining what points are necessary for the success of an automatic freight-car brake. The types of automatic brakes that are being brought to the notice of railroad companies for freight-car equipment may be classified under four general headings: 1. Buffer brakes; 2. Friction brakes; 3. Air brakes; and 4. Electric brakes.

1. Buffer Brakes.—Of these there are many patented, though few as yet in actual service. Three only were drawn to our attention in time for investigation, *i. e.*, the American brake, the Rote brake and the Prescott brake. Briefly described, the buffer brake consists of a connection with the brake levers, which engages or disengages from the back of the draw-bar; this connection is controlled in some cases by a governor secured to the axle, in others by hand adjustment. Any one draw-bar being compressed transmits the compression, and consequently applies the brakes throughout the entire train, regardless of whether they are continuously connected or not. The application is, of course, in accordance with the amount of resistance offered. Of this type we find the American the most largely introduced. Up to May 20th, they had equipped 2 815 cars.

The brake is controlled by a governor revolving with the axle; at low speed it is out of action, allowing the cars to be switched about a yard or pushed out of it in case of an up grade, without any interference of the brake. At speed it operated equally well whether moving forward or backward, and without any readjustment. The cost of the brake is $15 a car.

The Rote is also controlled by a governor attachment to the axle, but differing from the American in construction and action. Both are ready for application after from two to four miles of speed is reached, the Rote, however, only in pulling; it is inoperative in backing. Again, the former throws off automatically when the train comes to rest, while the latter remains applied until the compression of the draw-bars is removed by taking up the slack, an advantage for the Rote in running past a specific stop, such as a coal or water station, or in case of accidentally running an engine and car of a train off a stub switch, but a disadvantage if stopping on a downward grade. Ten cars of the New York, Pennsylvania and Ohio have been equipped with this brake for several months. Last December, we have been informed, a contract was made with the New York, New Haven and Hartford Company for the equipment of all its freight cars; none, however, have as yet been applied. The cost of the Rote brake, as mentioned in one of the company's circulars issued in December, 1884, is $31 per car. We are under the impression this includes application, which is not the case in the other figures we have given.

The Prescott brake has been in use some nine months on a train of cars of the Central Vermont Railroad; it is also in use on ten cars of the Delaware and Hudson Canal Company. It is rendered operative or inoperative by hand adjustment. It is only operative when pulling. In backing the brake has to be rendered inoperative, an obvious disadvantage. The cost is $8 per car.

2. Friction Brakes.—Under the second classification there are also numerous devices. Your Committee have investigated the Widdifield and Button only. It is in use experimentally on twelve cars of the Lehigh Valley Road. The compression of the draw-bar here acts by a system of levers on a pair of friction pulleys. One of these pulleys is of fiber and soft metal, and is cast on the axle; the other is of cast-iron, and is mounted on a transverse spindle, so arranged that the faces of the pulleys are brought in contact, producing, as before stated, an amount of retardation corresponding to the compression. The brake acts only in the direction in which the handle of the lever is thrown. When a train is to move forward, care must be taken that all the handles are pointing forward, and compression of the draw-bars will then apply the brakes; but they are inoperative in backing up. Should it be desirable to have the brakes operative in case of a long back up, it can be arranged by reversing this lever on each car. When the brakes are applied and the train is brought to a stop, they remain applied until the slack is taken up, as with the American; the Prescott, however, has this additional feature: In the above case the brakes may also be thrown off by putting the handle in a midway position; this cuts the brake out, whether applied or not applied. This cutting-out feature is important, as it allows the use of pushes up grades; temporarily, of course, doing away with the brake on the cars pushed, and necessitating a readjustment when the summit is reached. This brake may be seen by members of the Convention under the sample 60 000-pound box car (No. 7 599) of the Lehigh Valley. The cost of the brake is $10 per car.

3. Air Brakes.—Our next classification is the air brake, representing which we have taken the Westinghouse automatic. It is by far the most expensive brake, costing $50 per car, exclusive of fitting up; in addition to which it is necessary the engine be fitted with an air-pump, which, for each engine and tender, entails an additional outlay of $360. The brake, however, is very effective, and the only one your Committee con-

siders comes properly under the heading of automatic. Once coupled up it is ready for use, going in either direction, whether pushed or pulled, at low speed or high speed, and may be applied by the conductor, from the last car connected, to every car, including the engine, as well as by the engineer. The brakes do not act independently, as is the case with compression brakes, but they have to be connected continuously from the engine. Even with compression brakes, however, it should be borne in mind that with partially equipped trains, the most effective results are obtained when the cars are placed in the forward part of the train, as it is there they get the greatest compression. Notwithstanding the cost of the Westinghouse, we find it the most largely introduced. Up to May 18th, orders have been filled for 24 243 sets of automatic brakes. In addition to which, 6 806 sets of the Westinghouse non-automatic brakes are in use on the freight cars of five different lines.

4. Electric Brakes.—Your Committee have had no opportunity of investigating.

General Remarks.—In reviewing the foregoing, and without entering more fully into explanatory details, the main question to be considered by members of this association and managers of railroads seems to be a choice of two types of brakes—the automatic air brakes or the cheaper compression brakes. It will be said by some, this question of brakes is not a new one ; it is new, it is true, for freight service, but we have had an ample experience with various types of brakes in passenger service for years past, from the hand brake upward, resulting in the air brake being recognized and adopted by almost every railroad management in the country. If compression brakes are equal to or better than air brakes, why don't their advocates undertake to fit up our passenger equipment with them? A very natural reply is that the passenger equipment of railroad companies has had the expensive air brakes applied, and inasmuch as it does its work efficiently, it would be very difficult to have its place taken by any other types of brakes, even though superior in many features. The compression-brake advocates therefore recognize they will meet with more success by giving their attention to a field not yet so fully covered. This is a plausible, but, nevertheless, not a true answer to the question. The reason compression brakes are not applied to passenger equipment is because they do not fulfill the requirements of the service as well as air brakes. They are not automatic in every respect, as the air brake is ; a conductor or brakeman on any part of the train cannot at a moment's notice apply the brakes on every car and engine ; in case the train parts while running, the brakes are not instantaneously applied on every wheel of both sections of the train. These, together with other features, might be cited as making the air brake indispensable for passenger service.

Are not then the same points desirable for the success of an automatic freight-car brake? Your Committee think they are beyond any doubt desirable, but how to accomplish it is not so clear. In the United States and Canada there are some eight hundred thousand freight cars. To equip these with air brakes at $50 a car would cost $40,000,000 ; the same number of cars at $10 would cost $8,000.000. Compression brakes are unquestionably in advance of hand brakes, and with many lines might be available at $20 to $30 a car, but could not be considered at $50 and $60. Your Committee, therefore, recommend that in place of adopting any specific type of brake or brakes at this Convention, the subject be continued for further investigation; that the new committee be instructed to endeavor to have made a series of comparative tests

with trains wholly and partially equipped with such brakes as may be in actual service, and that the members urge their managers not to confine their experiments to any one brake, so that their representatives may come to the Convention ready to say what brake they are prepared to advocate, and fortified with their own experience for and against the less favored devices.

B. WELCH,
GEORGE HACKNEY,
GODFREY W. RHODES,
} *Committee.*

The discussion of the report by the members of the Master Car Builders' Convention, brought out the following statements from members present. One member said:

"If a good automatic freight-car brake were adopted, I am convinced that trains could be run much faster and safer, and that the repairs to cars would be decreased. If the means of running freight trains safely at twenty-five or thirty miles an hour were provided, the capacity of many roads would be doubled, and every man in the country is interested in bringing about a result of that kind."

In answer to the question whether the speed of trains could be accelerated by the use of an automatic freight brake, another member replied:

"It was with that object in view that we have adopted automatic brakes for part of our freight-car equipment. Experience with the use of the brakes has shown us that trains can be run much faster with perfect safety. An engineer told me that with seven cars having automatic brakes in the front end of a train, he could get over the road with safety and make much better time than when he had to depend upon brakemen."

The automatic brake referred to by this member was the Westinghouse. Another member mentioned a case where an engineer failed to stop a train in the distance calculated and had an accident. The cause of the mistake was that the capacity of the cars had been materially increased without a corresponding increase of brake power. Another member stated that he

"Found that wheels of cars near the hind end of a train often broke going down a long hill. The cause of this was that brakemen went out from the caboose and put on a few brakes behind, leaving them to do all the work, and so the wheels got hot and broke about the time the bottom of the grade was reached. An automatic brake would prevent this trouble by distributing the work over more wheels."

I have quoted the report of the Master Car Builders' Committee at length, with the discussion thereon, because it is the first instance that has come to my knowledge in which any systematic and combined effort has been made by railway officials to ascertain the value to their service of "power brakes." The term "automatic" is greatly misused in this report, as will be referred to hereafter.

The question of the necessity or desirability of power brakes is one that can very readily be determined.

By reference to the records of the road with which the writer was formerly officially connected, he finds that the weight of freight trains was in 1865—

On Eastern Division.

Engine	81 700 lbs.
Twelve loaded cars and caboose	520 000 "
Total	601 700 " or

300 tons 1 700 lbs.

On Western Division.

Engine	81 700 lbs.
Sixteen loaded cars and caboose	688 000 "
Total	769 700 " or

384 tons 1 700 lbs.

The standard freight train on the same road in 1885 is reported to me as follows:

On Eastern Division.

Engine	149 350 lbs.
Twenty-seven loaded cars and caboose	1 635 000 "
Total	1 784 350 " or

892 tons 350 lbs.

On Western Division.

Engine	127 450 lbs.
Twenty-nine loaded freight cars and caboose	1 755 000 "
Total	1 882 450 " or

941 tons 450 lbs.

Thus it will appear that the trains of 1885 bear in weight to the trains of 1865, the following proportions:

On Eastern Division.....2.97 to 1.
On Western Division.....2.45 to 1.

The following statement shows comparatively the weight of standard freight trains on the Pennsylvania Railroad in 1865 and 1885, as furnished by the officers of that company.

PENNSYLVANIA RAILROAD.

Weight of Standard Freight Trains.

Division.	From	To	1865. No. of Engines.	1865. Cars. Loaded.	1865. Cars. Empty.	1865. Weight in Pounds. Engine and Cars	1865. Weight in Pounds. Load.	1885. No. of Engines.	1885. Cars. Loaded.	1885. Cars. Empty.	1885. Weight in Pounds. Engine and Cars.	1885. Weight in Pounds. Load.	Comparative Totals. 1865. Tons.	1885. Tons.	Ratio
Philadelphia	52d Street	Columbia	1	18	....	411 500	252 000	1	30	....	854 250	600 000	332	727	2.19
"	"	"	1	....	30	639 500	.....	1	....	65	1 659 250	.....	320	830	2.59
"	Columbia	Harrisburg ...	1	40	....	829 500	560 000	1	65	....	1 659 250	1 300 000	695	1 480	2.13
"	"	"	1	....	65	1 304 500	.....	1	....	115	2 809 250	.....	652	1 405	2.15
"	Harrisburg ..	Columbia	1	25	....	544 500	550 000	1	70	....	1 774 250	2 800 000	547	2 287	4.18
"	Columbia	52d Street	1	25	....	544 500	550 000	1	35	....	969 250	1 400 000	547	1 185	2.17
Middle	Harrisburg ..	Tyrone	....	....	....	.....	.....	1	....	100	2 464 250	.....	....	1 232	....
"	"	Altoona	1	30	....	639 500	420 000	1	....	75	1 889 250	.....	530	945	1.80
"	Altoona.....	Mifflin	1	45	....	924 500	990 000	1	65	....	1 659 250	2 600 000	957	2 130	2.23
"	Mifflin.....	Harrisburg...	1	45	....	924 500	990 000	1	75	....	1 889 250	3 000 000	957	2 445	2.57
Pittsburgh ...	Altoona	Gallitzin	3*	32	....	816 500	448 000	3*	34	....	1 244 950	1 360 000	632	1 302	2.06
"	Gallitzin	Derry	1	32	....	677 500	448 000	1	34	....	946 250	1 360 000	563	1 153	2.06
"	Derry	Pittsburgh....	1	17	....	392 500	238 000	2	34	....	1 095 600	1 360 000	315	1 228	3.90
"	Pittsburgh....	Derry	1	16	....	383 500	352 000	2	34	....	1 095 600	1 360 000	368	1 228	3.34
"	Derry	Conemaugh...	1	32	....	697 500	704 000	1	34	....	946 250	1 360 000	701	1 153	1.64
"	Conemaugh ..	Gallitzin.....	2†	32	....	767 000	704 000	2†	34	....	1 095 600	1 360 000	735	1 228	1.67
"	Gallitzin	Altoona.....	1	32	....	697 500	704 000	1	34	....	946 250	1 360 000	701	1 153	1.64

* Mountain Division—Ascending grade 90 to 100 feet per mile.

† Mountain Division—Ascending grade 60 feet per mile.

Standard Freight Engine—weight — 1865 — 69 500 lbs. — 1885 — 149 350.
" " Car " " 19 000 " " 23 000.
" Caboose " " not used " 14 900.
" Load—Westward " " 14 000 lbs. " 20 000.
" " —Eastward " " 22 000 " " 40 000.

In addition to the increase in weight, there has resulted from the improvement in the condition of the track and machinery, a somewhat corresponding increase in speed, and where the maximum speed was formerly 15 miles per hour it is now 20 to 25 miles per hour. If we take the increase of speed from 15 to 20 miles per hour as a basis, it will represent an increase in momentum of 78 per cent., which, being applied to an increase of weight of 2.97 times, would indicate an increase in momentum in the proportion of 5.29 to 1, so that it is safe to assume that the momentum of the average through freight train on the main lines of railways is from *four to five times* that of twenty years ago. To meet this increase in momentum, a few railway companies have adopted the driver brake, but they are few. In most cases nothing more has been done than to increase the number of brakemen from *two* to *three*, and in a great majority of cases it is probable that even that increase in the braking force has not been provided. When we consider the enormous momentum of trains weighing from 1 000 to 2 500 tons running at a speed of twenty-five miles an hour down descending grades of fifty feet per mile, it should require no argument to demonstrate the *expediency*—not to say *necessity* of power brakes for freight trains.

Before commencing my experiments with power brakes, with a view of obtaining some information in regard to both the experience with power brakes, and the opinions of railway managers with regard to their necessity or desirability, I addressed a circular letter to the companies, by a blank to the executive officers of about one hundred and fifty railways. I received replies from forty-nine of them, of which the following quotations give the principal facts and opinions set forth.

The Hannibal and St. Joseph Railroad General Manager says:

"Think all engines and cars should be equipped with friction (power) brakes." He gives a case where the air brakes averted a collision on his road, the trains being fifty feet apart when stopped.

The New York, Pennsylvania and Ohio Railroad General Superintendent, Charles Paine, M. Am. Soc. C. E., in answer to the request for his opinion as to their use, in view of the greatly increased weight of engines, cars and trains, says:

"I have no opinion based upon experience here, but a firm conviction that they are very desirable. With power brakes the men can be removed from the top of the train, and, in consequence, overhead crossings be cheaply constructed wherever desirable. I judge that freight trains with power brakes could be run twice as fast as without, with equal and perhaps greater safety."

The Chesapeake and Ohio Railroad General Manager C. W. Smith says:

"In my opinion railroading will never approximate the perfection line until there is some means perfected by which a train of freight cars can be controlled by power derived from some other source besides the application of the hand brakes. Heavier and more powerful engines are being introduced; cars have jumped from twelve to twenty tons capacity in the past three or four years, and are still on the increase—some roads, as well as this company, having built cars of 50 000 lbs. capacity and in a few instances have reached 60 000 lbs. capacity—and no very great change has yet been made in the manner of checking the momentum of the trains. Take a train of fifty cars and a consolidation engine, of weight as follows:

Engine	53 tons.
Tender (loaded)	30 "
Light weight of cars	550 "
Weight of contents	1 000 "
We have	1 633 tons.

probably running twenty miles per hour, in charge of not over three brakemen and a conductor; in case of a sudden stop being necessary, it would not be possible for these men to put on more than two brakes each, if they were out on the train in place when the signal would be given to stop. With a power brake, under charge of the engineer, the safety of the rolling stock would be greatly increased and freight handled with greater dispatch. A power brake should be so constructed, that in case a train parts the detached cars will not run together; there is more damage done to property from this cause than from almost any other. The parting of the train while running should apply the brakes on all the cars; in other words, any brake adapted to freight cars, to accomplish the end desired, should be automatic in its action."

I would here remark that, in my opinion, Mr. Smith over-estimates the importance of having a brake that will be applied automatically in case of a train parting, as will be further set forth in this paper.

The Wisconsin Central Railroad General Manager says:

"I am very glad you have taken this matter up, and trust that you will bring out of it some arguments that will demonstrate the advisability of using power brakes on freight trains, and, beside the demonstration, influence the railroads to adopt something of that kind. We have the steam brake on two of our switching engines and they are doing good service."

The South Carolina Railway General Manager says:

"Any system of power brakes as well fitted for use on freight trains as the Westinghouse automatic is for passenger trains, would prove of great advantage to railway companies, both in additional safety and decreased expenses. But, in order to be put in general use, the freight-train brake must be made so as to act on each car independently of brake connection, either with the engine or with front cars in the train, else the expenditure required to put power brakes on all freight cars would prevent most railway companies from adopting them."

The Arkansas Valley Railroad General Manager says:

"Could we afford it, would put power brakes on all our locomotives. Have no doubt as to the advantages connected with their use."

The Columbus, Hocking Valley and Toledo Railroad General Superintendent says:

"The hand brakes, where the equipment is heavy, can be made correspondingly efficient. The weight of engines and cars, in my opinion, does not affect the question of the economy of or necessity for the use of a power brake."

This officer does not appear to recognize the fact that the effect of hand brakes is not limited by their strength or weight, but by the power of the man who applies them, and while the leverage by which the power is transmitted from the man to the brakes may be increased, it will be at the cost of making the application of the brakes slower and therefore requiring more time, whereby the brakeman will not be able to apply as many brakes. It should here be noted that the application of brakes to both trucks of a freight car, when applied by hand from one end of the car, does not increase the retarding power, as the pressure that has heretofore been exerted upon four wheels is thereby merely distributed upon eight, the only good effect being to enable that power to be used with less danger of sliding the wheels.

The New Haven and Northampton Railroad has 8 road and 4 switching engines and 100 freight cars equipped with power brakes. The General Superintendent says:

"The advantage of power brakes for freight engines is principally the saving of time in doing work; where there is switching it adds materially to the result, and, with trains en route, the tedious 'dragging' at stations and water plugs is diminished. The heavier the mass to be stopped the more adequate provision of brake should be supplied. If it can be done practically and satisfactorily by power, it is an economy over increasing hand labor. Our steam and air brakes are apparent successes. Much may be said of car brakes applied by concussion, or their own inertia, which may serve as a stepping-stone to something better, the efficiency of which will be more positive."

The Chicago, St. Paul, Minneapolis and Omaha Railroad General Superintendent says:

"It has been a noticeable fact on this road that engines equipped with air brakes (especially driver-brakes), seldom meet with rear collisions, and many rear collisions, in our experience, would have been averted if the engineer had had at his service so powerful an aid as a driver-brake."

The Georgia Railroad has 40 out of 44 freight engines equipped with power brakes. The General Manager says:

"The advantages found are a very largely increased brake power

placed where it will do the most good, *i. e.*, on the engine and in the hands of the engineer; also reduced train expenses, requiring fewer brakemen. We think we enjoy great immunity from rear collisions. Running our trains in sections on a single track road, we handle heavier trains with greater safety than we could possibly do without power brakes on drivers and tenders of engines." He gives an instance where the life of a child was saved by the use of the engine brake.

The Georges Creek and Cumberland Railroad has 6 freight engines, all equipped with steam brakes. The Manager says:

"Power brakes on our freight engines found necessary by exceeding heaviness of coal trains on descending gradient of 160 feet to the mile, 10 miles long. Trains weighing—cars and loads—about 1 200 tons. Speed, 11 miles per hour. Have found engine brake of very great assistance in controlling trains, and would not be without them for ten times their cost. Increased weight of engines and cars most certainly call for increased brake power, and for our service, at least, brake power should be applied to every wheel in the train. Latest practice of heavy engines and cars of large capacity call for the same, in my opinion. Have frequent recourse to the driver-brake in controlling trains which become somewhat unmanageable by reason of slippery rails and extraordinary deficiencies in car brakes in train. Had one very serious runaway on road before application of the driver-brake, which destroyed 55 coal cars, broke up 2 engines, killed 3 men and seriously injured 5 others, all of which would, in my opinion, have been averted by use of the driver-brake. Since application of latter we have never had a train at any time out of perfect control, and but for them I have no doubt we would have occasional accidents and severe damages. The driver-brake with us supplies apparently just the occasional deficiencies of the ordidary hand-power brakes of cars of our own and other companies which are handled upon our road. There is, in my opinion, a strong demand for power brakes on freight cars, which will render operations both on gradients and levels safer, more economical and more expeditious. The demand, however, is for a very simple construction, which does not require a high degree of intelligence to look after it and keep it up."

The Baltimore and Ohio Railroad has 326 freight engines out of 508 equipped with power brakes. The General Manager says:

"We have found the power brake of advantage in descending heavy grades. A good automatic power brake will be of great advantage on freight cars. It will be much more efficient than the hand brakes now in use."

The Cleveland, Columbus, Cincinnati and Indianapolis Railroad has 66 out of 183 engines equipped with power brakes. The General Manager says:

"The air brakes referred to are mostly on heavy Mogul engines. In service on the road in handling trains, we have found the brake to be very efficient, and in case of emergency to be better than any two brakemen that can be gotten on top of a freight train. In the handling of local trains while switching at stations, we find the brake indispensable. If we had the means we would equip every freight engine on our road with air brakes and every freight car as well. There can be no question of the economy and advisability of such adoption, especially in view of the demand for increased speed in moving freight trains."

The Central Vermont Railroad has 19 cars equipped with an automatic brake. The General Superintendent gives two instances in which the brakes on this limited number of cars saved serious accidents. In one, a collision with a train ahead was averted by having 7 cars with automatic brakes in the rear train. In the other, a collision with a train on siding, the switch being open, was prevented by having 10 cars with the automatic brake in the moving train.

The Pittsburgh and Lake Erie Railroad has 34 out of 36 engines equipped with the driver-brake. The General Manager says:

"We find a saving of one brakeman to each train and a decided saving of time in switching. I consider a power brake almost indispensable with the large freight engines and heavy trains we are handling. There have been numerous occasions when there would have been serious accidents and loss of property had we not had in use a power brake."

The Pittsburgh, Cincinnati and St. Louis Railroad has 133 out of 311 freight engines equipped with driver-brakes. The Manager says:

"The advantages of having the brake on freight engines are in the increased speed and equal safety with which long trains can be handled."

This road is noticeable as having been the one upon which the earliest experiments were made which resulted in the original Westinghouse air brake.

It is a cause of regret that but one-third the railway officers addressed by my circular took enough interest in the subject to send me a reply; but, on the other hand, the replies received, as are shown by the quotations above given, were decidedly encouraging. It will be specially noticeable that the experience of every company having the power brakes in use has been decidedly favorable to their general adoption, and good reasons are given why even a poor railroad company can afford to adopt a power brake. If the use of a driver-brake on the engine will "save a brakeman on each train," as the General Manager of the Pittsburgh and Lake Erie Railroad states; and if in case of accident "it is better than any two men that can be gotten on top of a freight train," as the General Manager of the Cleveland, Columbus, Cincinnati and Indianapolis Railroad states, there is ample reason for urging their adoption as a measure of the strictest economy.

Power brakes may be divided into two general classes, designated as "Continuous" and "Detached." Continuous brakes are such as require connection of some character from the engine to each car in the train containing the brake, which connection may be by a tube or pipe,

as in the case of the air brake; by wire, as in the case of the electrical brake; or by a cord or other equivalent device. Detached brakes are such as are complete upon each car, requiring no connection with the engine or from car to car. There are also brakes which partake of two or more of these characteristics, in which the brake apparatus is detached, so far as each car is concerned, but some portion of the apparatus is connected from car to car, and with the engine by a cord or rope for the purpose of setting or disengaging the brakes. These general classes may be again divided into sub-classes, of which the more important are

CONTINUOUS BRAKES.

Air brakes.
Vacuum brakes.
Electrical brakes.

DETACHED BRAKES.

Compression or buffer brakes.
Friction brakes.
Buffer and friction combined.

As before stated, there are upwards of 600 patents on power brakes applicable to railway engines and cars, and numerous additions are being made to the list every year. There are several parties claiming to have complete systems of power brakes applicable to the freight service, but most of them have never received any application beyond an experimental car, and in some cases the experiment has only been applied in the form of a model of a freight car. Finding it necessary, for the purpose of this investigation, to limit it to such brakes as had been or could be thoroughly tried, I decided to confine this paper to the consideration of such of the power brakes as had been put in practical use in a business way by railroad companies. To avoid possible misconstruction, those brakes which have not been investigated, in consequence of the limit thus decided upon, will not be mentioned even by name in this paper, and what is herein stated is without prejudice to them other than such opinion as may be formed in consequence of the fact that they have failed of adoption by railroad companies. This class of devices is particularly open to objections which can only

be developed in practical operation, and there are many of them which work satisfactorily in the model, and even appear to perform what is required of them when experimented with upon a single car, but which, in practice, will not meet the varied conditions and exigencies of actual freight traffic. In many cases a brake which will perform thoroughly what it is intended to do in stopping trains, fails utterly, because it will not meet the requirements in those things which it should not do. The application of this rule of actual service results in this paper being limited to the consideration of two brakes, viz.:

The Westinghouse Automatic (air) Brake.

The American Automatic Brake.

The companies owning these brakes have furnished me with statements, showing lists of railways in the United States using their brakes on freight cars, the number herein given being that of the cars furnished with their brakes up to July 1st, 1885. Their lists show the following:

WESTINGHOUSE AUTOMATIC.

Central Pacific Railroad	10 000
Union Pacific Railroad	3 620
Atchison, Topeka and Santa Fé Railroad	7 620
Galveston, Harrisburg and San Antonio	2 000
Northern Pacific Railroad	991
Pennsylvania Railroad	231
Other railroads in the United States	524
Total	24 986

WESTINGHOUSE NON-AUTOMATIC.

Denver and Rio Grande Railroad	2 466
Denver and Rio Grande Extension	3 150
Other railroads in the United States	194
Total	5 810

Total Westinghouse freight brakes in the United States, 30 796. The Westinghouse Company report in addition 551 automatic and 996 non-automatic freight brakes in use in foreign countries, and 10 111 sets additional of automatic brakes ordered but not yet furnished.

The company also furnishes a statement showing the number of its brakes applied to passenger engines as follows:

Automatic	8 238
Plain Air (non-automatic)	3 108
Total	11 346

It is probable that a small number of these engines are freight and switch engines, but the company does not so state.

The American Brake Company furnishes me with a statement of the names of the railroad companies, and the number furnished to each, of its steam-driver and tender brakes. The number of companies aggregates 112 having the American steam-driver and tender brake on 1 002 engines. These are presumably all freight and switching engines. The company also furnishes a statement of its automatic freight-car brakes in use as follows:

St. Louis and San Francisco Railroad	2 000
Wabash, St. Louis and Pacific Railroad	650
Other roads in the United States	165
Total	2 815

and states that the brakes on the St. Louis and San Francisco road have been in use on about 1 000 cars for three years, and on the other 1 000 cars for between one and two years.

The members of the Society are undoubtedly so familiar with the Westinghouse air brake, that any extended description of it would be superfluous. Suffice it to say that the ordinary air (non-automatic) brake of this company consists of an air-pump attached to the engine, in which the sizes of the air and steam cylinders are so proportioned as to give the necessary or desired air pressure when the steam in the boiler is at the normal pressure; a boiler-iron tank forming the main reservoir, generally located under the foot-board, and sometimes under the forward-end of the boiler; an engineer's brake-valve on the engine, by which the pressure of the air in the main reservoir may be admitted to the cylinders under the cars; a tube or pipe under each car with hose and couplings to form connection between the cars; and a brake-cylinder under each car, the piston of which is so connected with the brake-rods as to tranfer the force of the air pressure upon the piston to the brakes. There is also an air-cylinder upon the engine, the piston of which is connected with the brakes upon the driving-wheels, and an air-

cylinder under the tender connected with the brakes on the wheels of the tender. The air-brake, as originally designed and put in operation, developed a very dangerous tendency, in cases where trains were accidentally parted into two sections, to bring the sections into collision by reason of the connection with the rear section being destroyed. To meet this, a very important and ingenious arrangement was devised by Mr. Westinghouse, termed the automatic brake, the details of which, and its method of action, are perhaps not generally understood by the members of the Society, for which reason I append a description of the automatic brake as applied to freight cars, with reference to plates illustrating the apparatus.

The apparatus upon the engine for freight service is similar in all respects to that for passenger service, with the exception of its being larger in size, its capacity being about double that of the standard air-pump for passenger engines.

In the automatic brake there is on each car, in addition to the apparatus heretofore described as used in the air brake, a reservoir in which a supply of air is stored at the maximum pressure ready for immediate use upon that car.

Plate No. XXVIII shows the arrangement of the reservoir and brake-cylinders as applied to the freight car, all the reservoirs upon the train being filled with air at the standard pressure, and the pipes connecting them being also filled with air at the same pressure. It is provided that upon any reduction of pressure in the pipes the valve will be opened, admitting the air pressure from the car-reservoir to the brake-cylinder, thereby applying the brakes.

The requisite reduction in pressure in the air-pipes to bring the brakes into action may be brought about by either

1. The engineer opening his valve, permitting air to escape.

2. The conductor or brakeman opening a valve in the caboose, permitting the air to escape.

3. The parting of the train, bursting of a hose, disconnecting a coupling, or any other occurrence which shall cause air to escape from the air-pipes.

Plate No. XXIX shows the arrangement known as the "freight brake triple valve," which is a very ingenious arrangement, the description of which, and its application, I copy from the Westinghouse Company's catalogue, as follows:

The Westinghouse Automatic Brake.
Freight Brake Reservoir and Brake Cylinder.

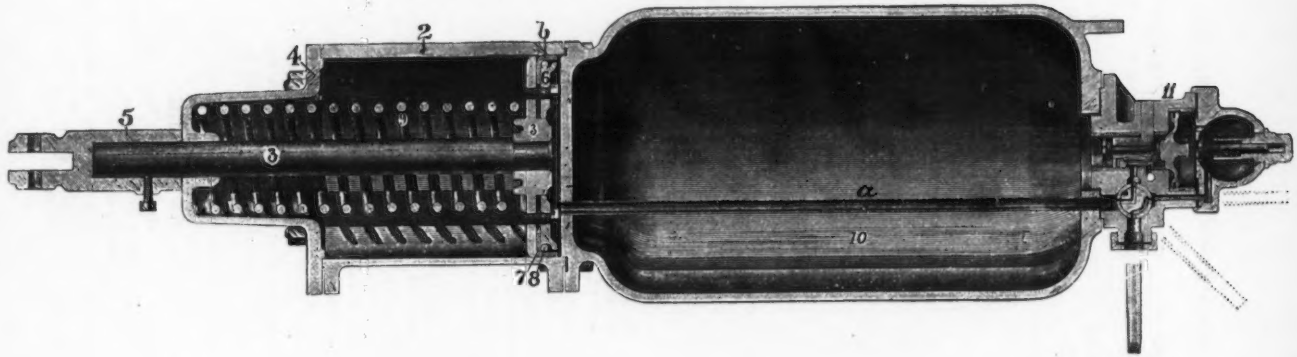

PLATE XXVIII.
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"The triple valve has a piston, 5, working in the chamber *B*, and carrying with it a slide valve, 6. Air enters from the main pipe through the four-way cock into the drain-cup *A*, and passes to the chamber *B*, forcing the piston up, and uncovering a small feeding groove in the upper part of the chamber, which permits air to flow past the piston into the auxiliary reservoir, while at the same time there is an open communication from the brake-cylinder to the atmosphere through the passages *d*, *e*, *f* and *g*. Air will continue to flow into the auxilary reservoir until it contains the same pressure as the main brake-pipe.

"To apply the brakes with their full force, the compressed air in the main brake-pipe is allowed to escape, when the greater pressure in the auxiliary reservoir forces the piston, 5, down below the feeding groove, thus preventing the return of air from the reservoir to the brake-pipe. As the piston descends, it moves with it the slide-valve, 6, so as to permit air to flow directly from the auxiliary reservoir into the brake-cylinder, which forces the pistons out and applies the brakes. The brakes are released by again admitting pressure into the main brake-pipe from the main reservoir, which pressure, being greater than that in the auxiliary reservoir, forces the piston, 5, back to the position shown in the drawing, recharges the reservoir, and at the same time permits the air in the brake-cylinders to escape. To apply the brakes gently, a slight reduction is made in the pressure in the main brake-pipe, which moves the piston down slowly until it is stopped by the graduating spring 9; at this point the opening 1 in the slide-valve is opposite the port *f*, and allows air from the auxiliary reservoir to feed through a hole in the side of the slide-valve, and through the opening 1 into the brake-cylinder. The passage 1 is opened and closed by a small valve, 7, which is attached to and moves with the piston 5, provision being made for a limited motion of these parts without moving the valve 6. When the pressure in the auxiliary reservoir has been reduced by expanding into the brake-cylinder until it is the same as the pressure in the main brake-pipe, the graduating spring pushes the piston up until the small valve 7 closes the feed-opening 1. This causes whatever pressure is in the brake-cylinder to be retained, thus applying the brakes with a force proportionate to the reduction of pressure in the brake-pipe.

"To prevent the application of the brakes from a slight reduction of pressure caused by leakage in the brake-pipe, a semicircular groove is cut in the body of the car cylinder, nine sixty-fourths of an inch in width and five sixty-fourths of an inch in depth, and extending so that the piston must travel three inches before the groove is covered with the packing leather. A small quantity of air, such as results from a leak, passing from the triple valve into the car cylinder, has the effect of moving the piston slightly forward, but not sufficiently to close the groove, which permits the air to flow out past the piston. If, however, the brakes are applied in the usual manner, the piston will be moved forward, notwithstanding the slight leak, and will cover the groove. It is very important that the groove shall be three inches long, and shall not exceed in area the dimensions given above. Heretofore we have used leakage valves, and have also had a leakage hole. These leakage holes we have found to be too uncertain in their operation, and we consequently recommend that these holes should be closed and the grooves in the cylinders substituted as rapidly as possible.

"When the handle of the four-way cock is turned down, there is a communication from the main brake-pipe to the brake-cylinder, the triple valve and auxiliary reservoir being cut out, and the apparatus

The Westinghouse Automatic Brake.

Freight Brake Triple Valve.

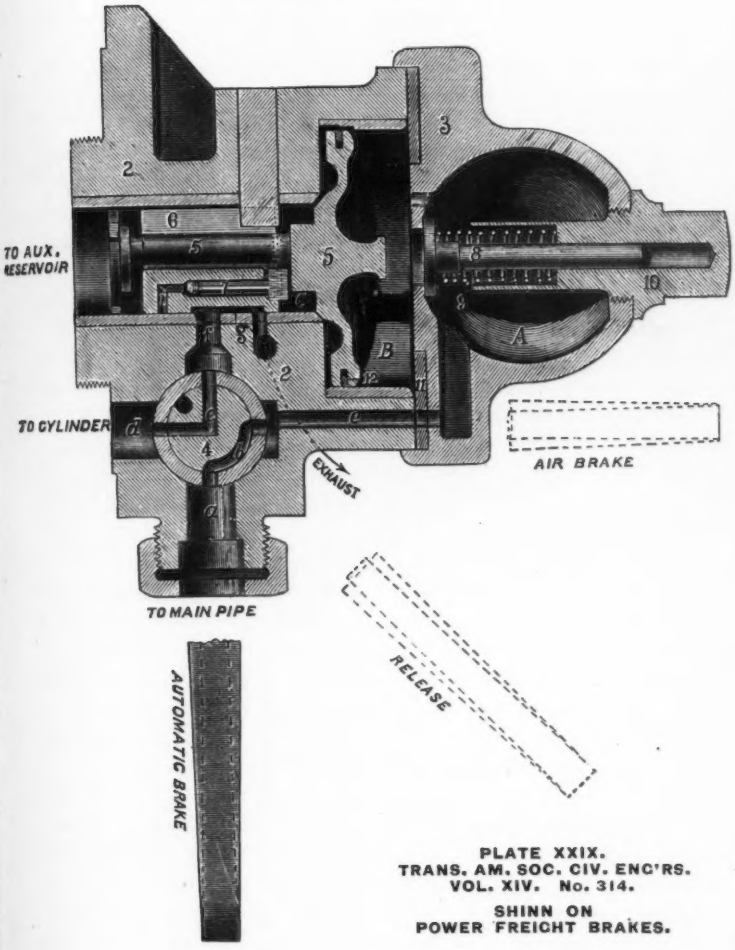

PLATE XXIX.
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can then be worked as a non-automatic brake by admitting the air into the main brake-pipe and brake-cylinder to apply the brakes. When, from any cause, it is desirable to have the brake inoperative on any particular car, the four-way cock is turned to an intermediate position, which shuts off the brake-cylinder and reservoir, leaving the main brake-pipe unobstructed to supply air to the remaining vehicles."

For more detailed description of the Westinghouse apparatus, members are referred to the catalogue of the company, which can be obtained by addressing the Westinghouse Air Brake Company, Pittsburgh, Pa.

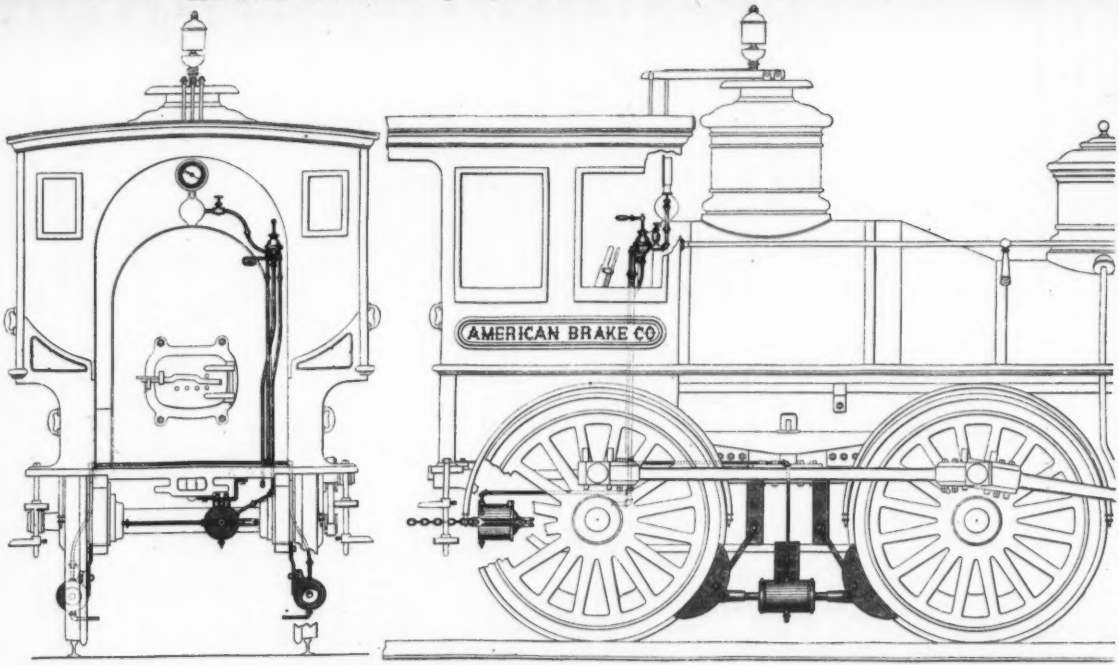
The American automatic brake being so limited in its use, I append a full description of its construction and method of operation with reference to plates illustrating its construction.

Plate No. XXX illustrates one of the arrangements of the American Brake Company's steam-driver and tender brake. This arrangement is used where the space between the drivers is sufficient to admit of it, but where the drivers are too close for this arrangement, a vertical cylinder is substituted, and in some cases the application of the brake is made on the outside instead of the inside of the driving wheels. There is a second cylinder under the foot-board of the engine, the piston of which is connected by a chain in the usual way with the brake-rods of the tender. This brake is brought into action by admitting steam to the cylinders at boiler pressure. The engineer's valve is of such construction that its first opening admits steam to the cylinder under the foot-board, thus applying the tender-brake first. A further movement of the valve admits steam to the cylinder of the driver-brake. It is claimed by the company that the arrangement of the driver-brake is such as to cushion against the shocks produced upon the brakes by the inequalities of the track. The whole apparatus is certainly very simple, and there appears to be no reason why it should not be thoroughly effective.

Plate No. XXXI shows the automatic brake as applied to the truck of a freight car, being an isometrical view of the arrangement.

Plate No. XXXII shows the same in ground plan, and Plate No. XXXIII shows it in side elevation. The figures indicating the parts are the same in all the plates, and the following is a brief description of the arrangement and method of its operation. This brake is of the class known as the "Compression" or "Buffer" brake. It is operated by the compression of the draw-bar, when, the motion of the engine being checked by application of the driver-brake or by encountering any obstruction, the momentum of the cars causes them to be brought forcibly together, thus

American Brake Company.—Steam Driver and Tender Brake.



compressing the draw-bars. The essential features of the brake are as follows: The push-bar (192), when the car is at rest, is in the position shown in Plate No. XXXI, when any compression of the draw-bar will not affect it. Thus the car can be pulled forward or backed, without in any way acting upon the push-bar. The push-bar is connected with a lever (42) extending downward, at the lower end of which it takes hold of the pull-rod (206), which is connected with the brake-lever by the relief-spring (185). The push-bar and its right angle lever (42) are so pivoted and connected that any pressure against the front of the push-bar, when it is in position to apply the brakes, will operate to force the lower end of the lever forward or toward the end of the car, thereby transferring the force by means of the pull-rod to the brake-lever, the remainder of the action being the same as when the power is applied to the brake-lever by hand. The most essential feature of this brake is the apparatus upon the axle, which is designed to prevent it from coming into action when the car is being moved at a low rate of speed, or when it is to be backed, and to cause the brake to be released promptly when the stop is made. This apparatus consists of the disc (151), which is suspended around but not attached to the axle. On the back of the disc are two flanges or plates, having two slots in each, in which the ends of the governor blocks (190) move outward and inward, by their motion causing the disc to be moved laterally on the axle. The governor blocks (190) are pivoted at their fastened ends to the axle clamp (1), the clamp being bolted securely to the axle. The governor blocks are held against the axle, when the car is at rest or moving at a slow rate of speed, by the volute springs (197). In front of the disc is the fork (5), which is suspended around the axle without touching it, and which is connected by the lower bell-crank rod (205), the bell-crank (72 *C*) and the upper bell-crank rod (30) to a hook on the upper side of the push-bar. The Plates Nos. XXXII and XXXIII show the parts when the push-bar is in position behind the draw-bar to apply the brake, the operation of which is thus described by the company:

"The upright lever (42) is suspended between the draft timbers, and carries in its upper jawed end the push-bar (192), which engages with or disengages from the inner end of the draw-bar according as it is lowered or raised by the centrifugal governor, which is securely fixed on the axle.

"When, by the rotation of the axle, the centrifugal force opens out the governor blocks (190), they draw towards themselves the disc (151) to which they are attached, and thus permit, by means of the fork (5) and

American Brake Company's Automatic Freight Car Brake.

Showing Position of Parts when Car is at Rest.

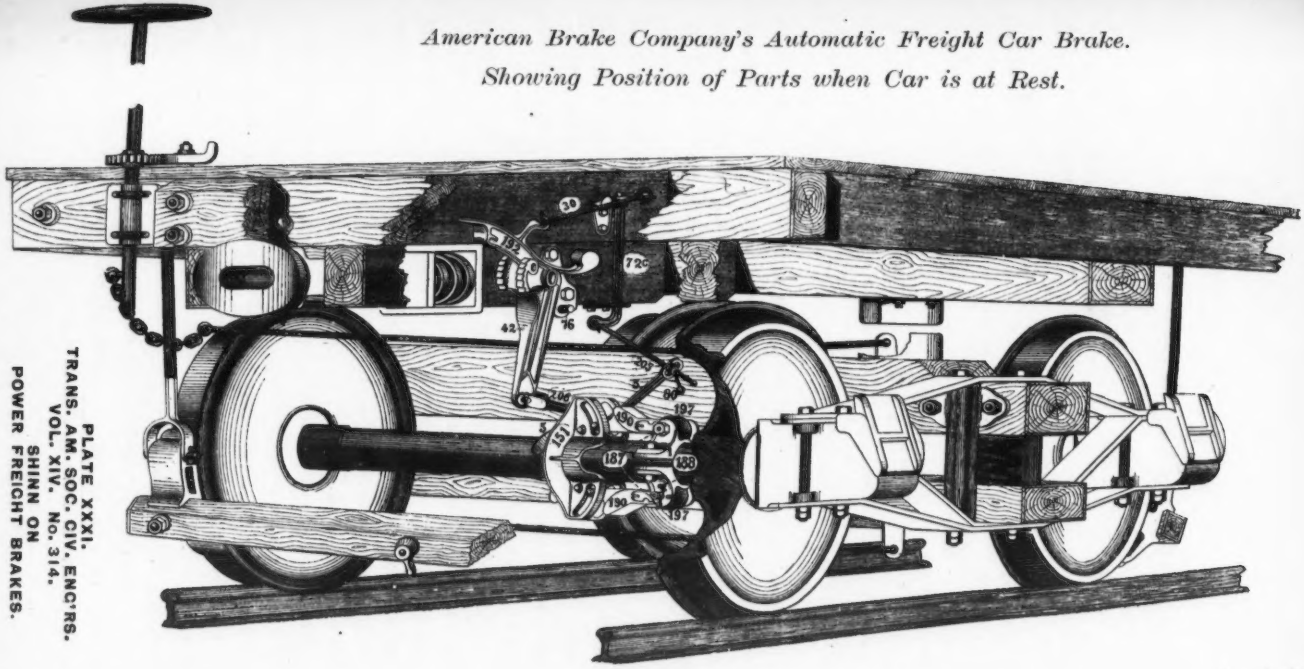


PLATE XXXI.
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rod connections (205 and 30), the push-bar to drop behind the draw-bar (see Plate XXXIII).

"When the axle ceases to revolve and the centrifugal force dies, the governor blocks are forced back and held by the volute springs (197), and by means of the same fork and rod connections lift the push-bar up and out of engagement with the draw-bar, so that the car can be backed without applying the brakes (see Plate XXXI).

"It is hardly necessary to explain that when the car is at speed and the push-bar consequently engaged behind the draw-bar, any compression of the latter, obtained by resistances offered at the head of the train, will necessarily apply the brakes by means of the forward movement of the lower end of the fulcrumed upright lever through its rod attachment to the end of the brake lever.

"The brakes will then be applied in proportion to the amount of resistances offered, but never so as to slip the wheels, for the amount of braking pressure diminishes as the speed of the car is checked. To prevent injury to the parts by reason of a sudden concussion, a relief spring (185) is interposed between the two levers as shown."

The weight of the governor blocks and the strength of the volute springs are so proportioned (or intended so to be) as to cause the blocks to remain against the axle till the speed of the car reaches six or eight miles per hour, when the centrifugal force of the governor blocks overcoming the pressure of the springs, causes them to separate, withdrawing the disc from the fork and allowing the push-bar to drop behind the draw-bar if the car is being pulled; if the car is being pushed, the draw-bar will be compressed and the push-bar cannot drop behind it until, by checking the engine, the draw-bars will be momentarily drawn out, when the push-bar will come into position to apply the brakes.

The company claims that when switching in yards or moving trains at a less speed than eight miles per hour, their motion can be sufficiently controlled by means of the driver and tender brake. Members desiring more detailed description of the brake and its action can obtain a catalogue by addressing the American Brake Co., St. Louis, Mo., or 160 Broadway, N. Y.

The reputation of the Westinghouse brake has been so thoroughly established in the passenger service, that I have not thought it necessary to personally test it in the freight service for the purposes of this paper, as it was not practicable to do so without a long journey to reach a road having a sufficient number of cars to readily furnish a full train equipped with the brake.

The Secretary of the Westinghouse Air Brake Company, in reply to my request for information in regard to their brake and its application to the freight service, wrote me in part as follows:

The American Automatic Brake.

Plan View, Showing Position of Parts when Car is at Speed.

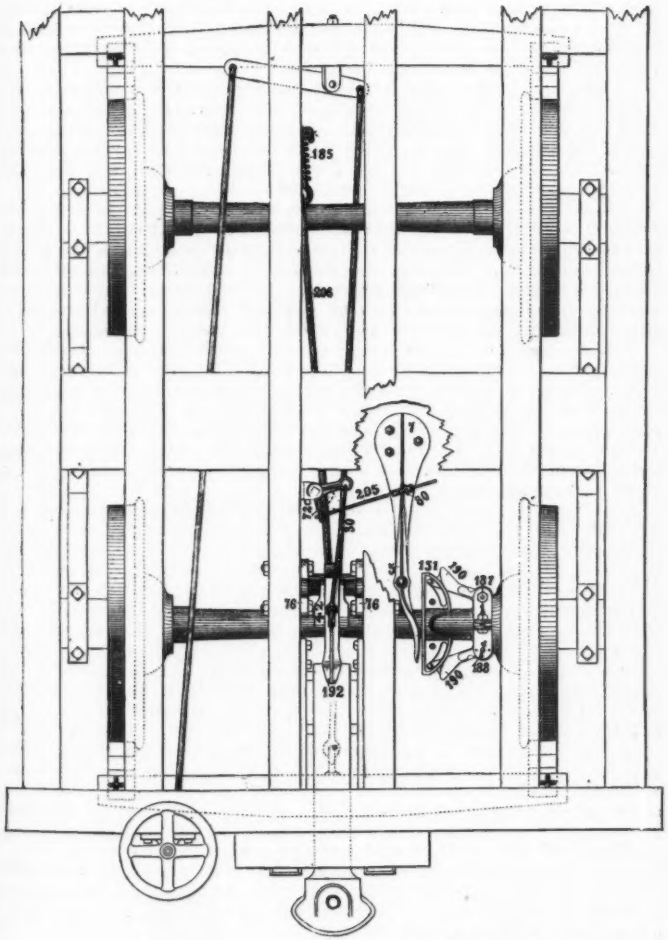

PLATE XXXII.
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SHINN ON
POWER FREIGHT BRAKES.

"We always insist that brakes be applied to both trucks, as good braking cannot be done when applied to only one truck. Since the commencement of the introduction of the Westinghouse air brake in 1869, the brake question has attracted the attention of inventors wherever railways are in use. Other forms of compressed air, vacuum, steam, electric, various forms of chain brakes, and an endless variety of the so-called concussion brakes, where the braking power is derived from the impact of the draw-head, have been tried.

"The first trial of the Westinghouse air brake was made on the Steubenville accommodation train upon the Pittsburgh, Cincinnati and St. Louis Railway. Its adaptibility in placing the train under the control of the engineer, and the quick stops that could be made, attracted the attention of the officers of the Pennsylvania Railroad, and soon led to its introduction on all the trains of that road.

"Mr. Westinghouse was quick to perceive the defects of his first invention; while the brake could stop a train in as short time and distance as was consistent with safety, still if a hose or pipe burst the brake became powerless. The engineer, depending upon the brake, often exposed his train to danger and accident. This led to the introduction of the automatic brake, which, however, required years of careful investigation and improvement before the brake now in use was perfected.

"The success of the Westinghouse automatic brake, as applied to passenger trains all over the world, is too well known to require comment. More can be said in favor of the automatic brake for freight trains than for passenger trains. While passenger trains are run at a high rate of speed, and are freighted with valuable lives, freight trains on most roads are more numerous than passenger trains, and the rolling stock less substantial, the trains longer and more unwieldy, consequently more liable to accident.

"It requires no argument to prove that when freight trains are equipped with automatic brakes, the number of accidents will be greatly decreased. That disastrous class of accidents caused by trains breaking in two, and the separated parts colliding, will be entirely avoided. In regard to collisions, derailments, etc., the same arguments can be used; the engineer, having the power at his command to stop the train in the shortest possible distance consistent with safety, will prevent most of these disasters, which otherwise are inevitable and beyond his control. Competition in railway traffic has necessitated the introduction of larger and stronger cars. From a load of ten tons it has increased to twenty and even thirty tons. Increased speed has also become necessary, and the limit of 15 miles per hour has been doubled. With automatic brakes the train can be brought instantly under control of the engineer, and is safer to run at a speed of 30 or even 40 miles per hour than with the hand brakes at 15. This is substantiated in the report of trials accompanying this letter, where trains running at a speed of 35 miles per hour were stopped within a distance of 200 yards; and trains are handled with perfect safety on descending gradients of 4 per cent. The capacity of a railway from a given amount of rolling stock and track can, by reason of increased speed and safety, be nearly doubled, to say nothing of the importance of quick time in delivering freight, which cannot help inducing traffic."

The Westinghouse Air Brake Co. has also, at my request, furnished me with reports of stops made by trains equipped with their brake on the Central Pacific Railroad, the Atchison, Topeka and Santa Fé Railroad,

The American Automatic Brake.

Side Elevation, Showing Position of Parts when Car is at Speed.

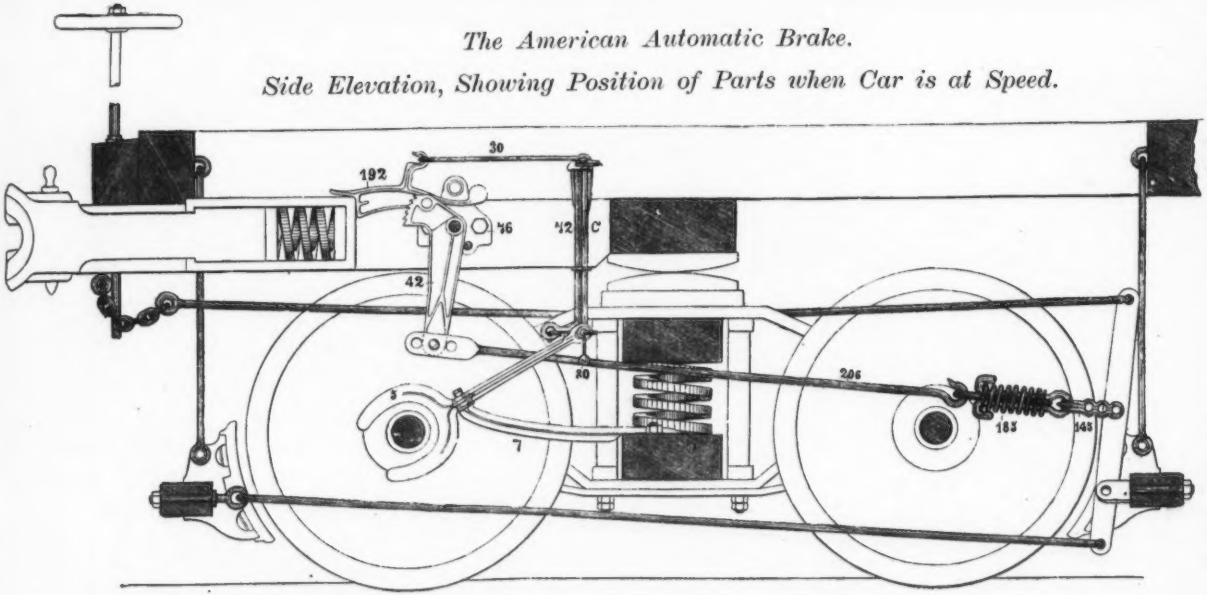


PLATE XXXIII.
TRANS. AM. SOC. CIV. ENG'RS.
VOL. XIV., No. 314.

and the Denver and South Park Railroad, the details of which are set forth in Schedule No. 1, and shown graphically by diagrams in Plate No. XXXIV. The General Manager of the Southern Pacific Railroad Co., in a letter to the Westinghouse Air Brake Co., giving the results of tests made on the Central Pacific road, reports as follows:

"The working of the brake was reliable and most satisfactory under all circumstances attending the trial. Of this, however, we had no doubt. Our experience of the brake in daily service upon all portions of the line has been such as to satisfy us fully as to its efficiency; it is reliable under all circumstances, and its working is such as to inspire full confidence in the minds of train men as to its safety and efficiency, not only on the level portions of the line, but on the long and steep gradients as well.

"The tests were conducted under the immediate supervision of our division superintendent, assistant general master mechanic, division master mechanic, master car-builder and assistant, and your own representative." Then follow the details of the stops, which will be found in the schedule. Of the test indicated in the Schedule as "G," he says: "The pin was pulled in the center of the train, leaving the engine and 13 cars in first section, and caboose and 11 cars in the second section. At the time the train was thus parted the speed was 35.06 miles per hour on a nearly level grade; the first section ran 665 feet and the second section 630 feet to a full stop.

"During these tests the rails were dry and in perfect surface. Nothing was found in the working of the brake to detract in the least degree from its merits as an efficient safety brake.

"In conclusion, I would specially call your attention to test B, where the train running 20.77 miles per hour down a 116-feet grade was brought to a full stop in 622 feet, or 196 feet less than the length of the train; also to test G, on a descending and nearly level portion of road, at the speed of 35.06 miles per hour, the first section with engine was brought to a full stop in 665 feet, or in one and about one-third of its length."

The Superintendent of the Atchison, Topeka and Santa Fé Railroad reports to the general manager upon the stops made on that road, details of which are given in Schedule No. 1. Speed of train in each case was estimated, which leaves a large margin for error. He says of the stop indicated by K in Schedule No. 1:

"This stop was made at bridge 75, west of Barclay, on a straight track and level grade. The last 15 cars on the rear end had the air 'cut out,' and the pin was pulled on the 16th car from the rear, thus leaving but one car with air to stop the 15 cars behind it without air; estimated rate of speed 32 miles per hour. This test was made to prove that a large number of cars without air behind one or more cars with air would not telescope forward portion of train with air. When the hose first parted the two sections separated about 6 feet, and then gradually closed up without concussion, the forward portion stopping both sections."

The Superintendent of the Denver and South Park Railroad, in a letter

to the Secretary of the Westinghouse Air Brake Co., giving the report of the experiments on that road, says:

"The officers of the road take pleasure in saying to me that prior to the time of using the automatic brake, they would take out from 500 to 600 pairs of flattened wheels per month, caused by sliding. They have now reduced this item to a very small figure. For instance, for the month of April there were only 17 pairs flattened and they were not taken out, as it was considered perfectly safe to run with them. They have taken out only 10 pairs of flattened wheels from their passenger cars in the two years the automatic brake has been in use. This certainly speaks in thundering tones for the brake. They are wonderfully pleased with the brake to say the least. I might add, in conclusion, that the rails were dry when the experiments were made."

Reference to the Schedule No. 1 will show the details of these stops so far as furnished me in the report. There is no information given as to how the speed and distance run were determined, nor whether the time was taken by a stop watch or an ordinary watch. In the case of the experiments on the Central Pacific Railroad, I would infer from the speed being given in fractions of miles that it was taken accurately, but have no means of knowing how the distance was arrived at. It is frequently estimated by counting telegraph poles, which introduces, to say the least, a very uncertain element into the case. On the Atchison, Topeka and Sante Fé Railroad, the report states that the speed was estimated, and as the distances are given in round figures it is probable that they also were estimated. No information is given in the report on the Denver and South Park, but the relations of the speed, time and distance run to each other, indicate that one or more of these elements were arrived at by estimate, which in many cases is only another word for *guess*. The diagrams in Plate No. XXXIV are necessarily hypothetical. They are made for purposes of approximate comparison with the diagrams of the stops made with the American brake, and I was obliged to assume a uniform reduction in speed during the whole period of the stop, which is not at all probable. The main features, however, being the time and distance run, it affords some basis of comparison, and certainly makes a very favorable showing for the Westinghouse Automatic Brake.

SCHEDULE No. 1.

STOPS MADE WITH WESTINGHOUSE AUTOMATIC BRAKE, SHOWN ON PLATE No. XXXIV.

On Central Pacific Railroad.—Train—Engine, 24 loaded cars and caboose.—Weight, 526 tons, 1 040 pounds; length, 818 feet.

Line on Plate XXXIV.	Grade. Feet per Mile.	Initial Speed. Miles per Hour.	Stop made in		Remarks.
			Time. Seconds	Distance Feet.	
	Descending.				
A	116	24.76	25	784	Engine detached.
B	116	20.77	22	622	do. sand used.
C	116	16.66	14	310	do.
D	116	13.75	16	322	Engine attached, sand used.
E	Level.	27.27	15	396	Engine detached.
F	do	24.54	16	420	do. sand used.
G	do.	35.06	22	{ 665 / 630	Engine and 13 cars detached.

On Atchison, Topeka and Santa Fé Railroad.—Train—Engine and 39 empty stock cars.

		About			
H	53 des.	30	20	630	
I	43 des.	30	14	360	
	26 asc.				
K	41 des.	32	10	....	Train divided, sections stopped 210 feet apart.
	53 asc.				
L	Level.	35	20	600	
M	53 des.	34	14	{ 800 / 550	Train divided in center.

On Denver and South Park Railroad.—Train—Engine and 18 loaded cars.

N	175 des.	30	20	975	
O	100 "	25	17	{ 630 / 510	Train divided, 11 cars in rear.
P	Level.	35	19	630	
Q	do.	38	..	{ 705 / 585	Train divided, 11 cars in rear.

In all of the stops recorded above, all the wheels had brakes applied to them. Therefore, percentage of wheels with brakes, 100.

Hypothetical Diagram of stops of Freight train made with Westinghouse Automatic Brake.

Speed miles per hour.
On Central Pacific Rail Road.
116 feet Grade.
Train - Engine, 24 loaded cars, caboose.
Weight 526 tons.
Length 818 feet.
Seconds.
Record
Line | Grade Feet | Speed Miles | Time Seconds | Distance Feet | Remarks.
A | 116. | 24-18 | 25 | 784 | Engine detached
B | " | 20-77 | 22 | 622 | do
C | " | 1666 | 14 | 370 | Engine brake used.
D | " | 13-75 | 16 | 322 | Engine detached.
On Central Pacific Rail Road.
Level.
Train-Engine, 24 loaded cars, caboose
Weight 526 tons.
Length 818 feet.
Record
Line | Grade Feet | Speed Miles | Time Seconds | Distance Feet. | Remarks.
E | Level | 27-27 | 15 | 396 | Engine detached
F | " | 24-34 | 16 | 420 | do.
G | " | 35-06 | 22 | 665 / 630 | Engine & 13 cars detached
On A.T.& S.F.R.R.
Various Grades.
Train - Engine and
39 empty stock cars.
Record
Line | Grade Feet | Speed Miles | Time Seconds | Distance Feet | Remarks.
H | 53 | 30± | 20 | 630 | Engine & all cars with brakes.
J | 53 / 52 comp. | 30± | 14 | 360 | do.
K | 52 comp. | 32± | 10 | | Train divided
L | Level | 35± | 20 | 600 | Engine & all cars with brakes.
M | 53 | 34± | 14 | 800 / 350 | Train divided in center.
On D.& S.P.R.R.
Various Grades.
Train-Engine & 18 loaded cars
Record.
Line. | Grade Feet. | Speed Miles | Time Seconds | Dist. Feet | Remarks.
N | 175 | 30 | 20 | 975 | Engine & all cars with brakes
O | 100 | 25 | 17 | 10 & 30 / 510 | Train divided, Hears in rear.
P | Level | 35 | 19 | 630 | Engine & all cars with brakes.
Speed miles per hour.

When I decided, upon the grounds heretofore set forth, to investigate the American Brake Company's devices, I called upon the officers of that company to provide a fully equipped train of engine and cars, and also to furnish such apparatus as would be necessary to enable the test to be made accurately.

The company met my request by equipping a 61-ton engine with their driver and tender brake, and 12 coal cars and 2 box cars with their automatic freight-brake, and a box car (herein termed the "gauge car") with the following described apparatus:

A speed recorder, driven by a belt from the axle of the car, and so arranged as to show on one dial (by an indicator similar to that on a steam-gauge) the rate of speed in miles per hour at which the train was at the moment running; another dial, with a clutch connection so arranged as to be automatically put in operation when the brake was applied, showed the distance run in feet from the time the brake was applied until the train was stopped.

The gauge car was also provided with an apparatus, consisting of a clock movement so arranged as to propel a sheet of diagram paper, which was traversed transversely by a cross-head carrying a pencil and moving upon guides. This cross-head was connected with one end of a lever, the other end of which, in the trials made in June on the Missouri Pacific Railroad, was connected with the draw-bar spring at one end of the gauge car. This draw-bar spring was tested in compression, so as to ascertain the amount of pressure required to compress it for each quarter of an inch, and the lever connecting it with the cross-head was so arranged as to cause a movement in the cross-head of three-quarters of an inch for each quarter of an inch compression or extension of the spring. By means of this apparatus a diagram was made automatically, indicating the varying pressure upon the draw-bar during the whole period covered by the stop. The clock-work was capable of being varied in speed, and during the early experiments it was run at a speed which propelled the paper about one inch per second.

Before the test stops on the New York, West Shore and Buffalo Railroad were begun, this apparatus was changed to the other end of the gauge car, where the lever connected with the cross-head was at its other end connected with a spring in such a manner that the spring should receive the strain which would normally come upon the pull-rod of the brake; this spring was tested in like manner, and a diagram made auto-

matically with the apparatus in this position shows the strain on the pull-rod at each instant of the stop. The speed of the clock-work in the last named position was arranged to move the paper at about one-half inch per second.

The leverage of the brake is such that the pressure on one pair of wheels would be twice, and on the other pair of wheels three times the strain upon the pull-rod.

Diagrams showing the strain during several of the stops made will be found on Plate No. XLII, and a diagram illustrating the pressure upon the draw-bar will be found on Plate No. XLIII, to both of which reference will be made hereafter.

The speed gauge and distance gauge were thoroughly tested by being connected with an engine, the revolutions of which were registered; and they were subsequently tested in actual operation on the track by comparing the speed shown by the speed gauge with the time required to run a mile, and the distance, as shown by the distance gauge, in like manner with the measured distance on the track, and both were found to correspond with satisfactory accuracy, the error in the distance gauge being less than one per cent.

The time was taken with a stop watch, which, during all the tests witnessed by me, was held by myself. The watch was started upon the application of the brake, and I called out at each ten seconds during the stop, while one assistant noted the speed at that instant by the speed gauge, and another noted the distance run by the distance gauge. When the stop was completed I stopped the watch, and then took the total time from it, and the total distance from the distance gauge. I also personally noted the speed by the speed gauge at the moment the brake was applied. With these precautions I was able to obtain a very satisfactory record to enable me to produce an approximately accurate diagram of each stop witnessed.

Stops Nos. 1 to 47 in Schedules 2, 3 and 4 were made under the personal supervision of the writer; Nos. 48 to 87 were made under his direction, but were not witnessed by him.

After spending two days in making the test stops on the Carondelet Branch of the Missouri Pacific Railway, to wit:

June 18th, with experimental train of empty cars.

June 20th, with the same train, 12 cars loaded, during which the stops were made indicated in Schedules 2, 3 and 4 as numbers 1 to 47,

I directed other tests to be made on the same road, which was done as I directed, and the results were reported to me in detail, and appear in Schedules 2, 3 and 4 as numbers 48 to 87 inclusive. During the making of these stops, the box car containing the recording and indicating apparatus (generally referred to as the "gauge car") was placed for about one-half the time at the front of the train or next the tender, and during the balance of the time in the middle of the train, the only difference in results being in the character of the pressure and strain diagrams obtained.

The diagram of "Pressure on Draw-bar," indicated in Plate No. XLIII, was taken with the gauge car in the middle of the train; of the diagrams of "Strain on Bottom-rod," shown in Plate No. XLII, line *A*, was taken with the gauge car in the middle of train, and is a typical diagram for that position; the other lines, *B* to *H*, were taken with the gauge car in front, and indicate the greater strain on rod and consequent pressure on the brakes of cars in that position.

The experimental tests of the American Brake Company's engine and automatic freight car brake were begun on the Carondelet Branch of the Missouri Pacific Railway on June 18, 1885, with a train consisting of Wabash, St. Louis and Pacific Railway engine No 1406, weighing 73 100 lbs., tender (with coal and water), 50 000 lbs.; 3 box cars, 12 coal cars and 1 caboose. Length of train, 540 feet; weight, with cars empty, 213 tons; weight, with cars loaded, $400\frac{7}{10}$ tons; engine, weight on drivers, 46 200 lbs.

The stops were made on descending grades of 57, $52\frac{8}{10}$ and 18 feet per mile respectively.

SCHEDULE No. 2

shows the stops made on the descending grade of 57 feet per mile.

Stops made with American Automatic Brake on Missouri Pacific Railway, Carondelet Branch.

Number of Stop.	Weight of Train. Tons.	Brake Used.		Initial Speed. Miles per Hour.	Speed at each 10 Seconds.								Stops Made.	
		Kind.	Per Cent. of Wheels.		10	20	30	40	50	60	70	80	Time. Seconds	Distance. Feet.
1	213	Double.	87	25	17	..	..	..	..	..	..	..	18½	608
2	"	"	"	25	..	..	..	..	..	..	..	..	...	417
3	"	"	"	30	25	16	..	..	..	..	..	..	29½	780
4	"	"	"	30	19	..	..	..	..	..	..	..	23	570
6	"	"	"	38	34	29	23	13	..	..	..	..	50	1 670
8	"	Note *a*	"	26	..	..	..	..	..	..	..	..	125	2 140
11	"	" *b*	"	32	27	25	23	17	13	7	..	..	68	1 680
12	"	Single.	43½	30	24	16	9	..	..	..	..	..	34	840
13	"	"	"	32	24	17	9	..	..	..	..	..	35	1 030
14	"	"	"	30	23	16	6	..	..	..	..	..	34	....
17	400	Double.	87	25	22	17	12	..	..	..	..	..	42	867
39	"	Single.	43½	25	22	21	19	17	16	14	12	9	84	1 740
48	"	Note *c*	"	25	25	23	21	18	15	12	4	..	77	1 623
67	"	" *d*	"	25	21	16	11	..	..	..	..	..	44	814

Note *a* Stop No. 8, with engine cut off, 1 hand brake set on forward car, and automatics set thereby.

" *b* " " 11. Same as No. 8, except 3 hand brakes set.

" *c* " " 48. Driver and tender brake and 3 hand brakes set; automatics cut out.

" *d* " " 67. Automatic brakes used on forward 7 cars, balance cut out.

Brakes on both trucks, when so used, are called "double" brakes. When brake on but one truck is used, it is designated "single" brake. When the American automatic devices are cut out, and brakes are set by hand, it is designated as "hand brakes."

The stops made on the Missouri Pacific Railway on the descending grade of $52\frac{8}{10}$ feet per mile are shown graphically in the diagram on Plate No. XXXV, the stops at the same speed and under the same conditions being averaged, and the diagram lines show such average. The details of the stops are shown in Schedule No. 3.

SCHEDULE No. 3.

Stops made with American Automatic Brake on Missouri Pacific Railway, Carondelet Branch, on grade $52\frac{5}{16}$ feet per mile descending.

Number of Stop.	Letter on Plate No. XXXV.	Weight of Train. Tons.	Brake Used.		Initial Speed. Miles per Hour.	Speed at each 10 Seconds.								Stops Made.	
			Kind.	Per Cent. of Wheels.		10	20	30	40	50	60	70	80	Time. Seconds	Distance. Feet.
5	.....	213	Double.	87	37	..	..	..	..	..	..	..	..	55	1 780
7	.....	"	"	"	32	26	18	7	..	..	..	..	..	32	1 038
9	.....	"	Note *e*	"	32	..	..	..	..	..	..	..	..	..	3 800
10	.....	"	" *f*	"	30	..	..	..	..	..	..	..	..	48	1 260
15	Note *g*	"	Single.	$43\frac{1}{2}$	20	14	..	..	..	..	..	..	..	21	422
16	" "	"	"	"	20	13	..	..	..	..	..	..	..	18	370
18	*G*	400	Double.	87	25	22	16	9	..	..	..	..	..	35	840
19	*G*	"	"	"	25	22	17	12	1	..	..	..	..	41	935
20	.....	"	"	"	22	18	14	11	..	..	..	..	..	42	833
21	*A*	"	"	"	20	18	15	12	8	..	..	..	..	50	928
23	*A*	"	"	"	20	18	15	12	9	..	..	..	..	50	948
25	*G*	"	"	"	25	20	17	13	11	3	..	..	..	54	1 117
27	*G*	"	"	"	25	17	14	11	..	..	..	..	..	50	990
29	.....	"	"	"	23	17	15	13	10	2	..	..	..	55	908
31	.....	"	"	"	21	16	14	11	4	..	..	..	..	45	805
33	*A*	"	"	"	20	16	14	11	3	..	..	..	..	45	776
35	.....	"	"	"	17	8	..	..	..	..	..	..	..	15	213
37	*H*	"	"	"	30	24	19	14	8	..	..	..	..	45	1 130
40	*B*	"	Single.	$43\frac{1}{2}$	20	16	15	13	11	4	..	..	..	56	983
42	*B*	"	"	"	20	17	16	13	10	1	..	..	..	52	995
44	*J*	"	"	"	25	22	19	16	12	7	..	..	..	56	1 275
46	*C*	"	Note *h*	"	20	20	18	16	15	12	8	..	..	77	1 253
49	.....	"	" *j*	"	25	26	25	24	21	18	14	10	..	83	2 058
51	.....	"	" "	"	20	21	19	16	13	8	..	..	..	63	1 260
53	*K*	"	" *k*	"	25	25	25	24	21	18	14	11	3	87	2 200
55	*D*	"	" "	"	20	22	23	22	21	19	18	16	13	110	2 620
57	*C*	"	" *h*	"	20	20	20	18	17	16	14	12	11	110	2 006
59	Note *l*	"	Double.	87	25	24	20	16	12	..	..	..	..	55	1 188
61	" "	"	"	"	20	16	13	6	..	..	..	..	..	36	650
63	.....	"	"	"	18	16	12	..	..	..	..	..	..	30	385
65	Note *m*	"	"	"	20	20	19	18	17	16	15	12	10	106	2 060
68	" *n*	"	"	43	25	24	17	12	6	..	..	..	..	45	893
70	" "	"	"	"	20	16	14	10	4	..	..	..	..	45	816
72	" *o*	"	"	"	25	23	20	17	14	11	5	..	..	67	1 350
74	" "	"	"	"	20	18	16	14	10	3	..	..	..	55	1 038
76	" *p*	"	Single.	$21\frac{1}{2}$	25	22	19	16	12	8	..	..	..	61	1 330
78	" "	"	"	"	21	18	16	12	8	..	..	..	..	50	945
80	*L*	224	Double.	77	25	17	11	..	..	..	..	..	..	28	643
82	*E*	"	"	"	20	14	4	..	..	..	..	..	..	23	398
84	*M*	"	Single.	$38\frac{1}{2}$	25	20	15	10	..	..	..	..	..	39	830
86	*F*	"	"	"	$21\frac{1}{2}$	17	12	3	..	..	..	..	..	33	628

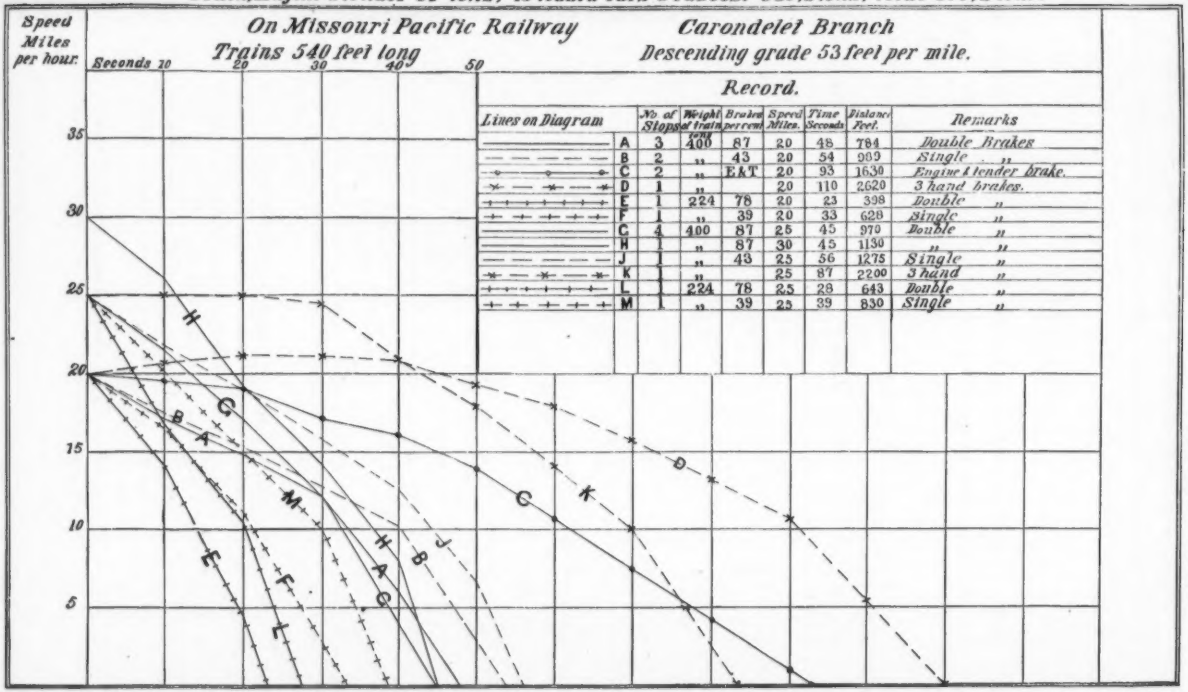
Note *e* Stop No. 9. Engine detached; 1 hand brake set, engaging automatics.
" *f* " " 10. " " 3 " " " " " "
" *g* " " 15 and 16, on 45 feet descending grade.
" *h* " " 46 and 57, with engine and tender brake only.
" *j* " " 49 and 51. Engine and tender and hand brakes only, 3 brakemen.
" *k* " " 53 and 55. 3 brakemen, hand brakes only used.
" *l* " " 59 and 61. Engine brake applied five seconds after tender brake.
" *m* " " 65. Engine detached, 2 hand brakes set; engaging automatics.
" *n* " " 68 and 70 Brakes used on 7 cars only.
" *o* " " 72 and 74. Brakes used on alternate cars only.
" *p* " " 76 and 78. 1 brake " " " " "
" *q* " " 80 and 82. Train reduced to 8 cars and caboose; 7 with brakes.
" *r* " " 84 and 86. Same train; 1 brake used on 7 cars.

Diagram of stops made by Freight Trains with American Automatic Brake.

Train, Engine & tender 61 tons; 15 loaded cars & caboose 339⅞ tons; total 400⅞ tons.

On Missouri Pacific Railway — *Carondelet Branch*

Trains 540 feet long — *Descending grade 53 feet per mile.*



Record.

Lines on Diagram		No. of Stops	Weight of train Tons	Brakes per cent	Speed Miles.	Time Seconds	Distance Feet.	Remarks
———	A	3	400	87	20	48	784	Double Brakes
— — —	B	2	"	43	20	54	909	Single "
-o-o-	C	2	"	E&T	20	93	1630	Engine & tender brake.
-×-×-	D	1	"		20	110	2620	3 hand brakes.
-+-+-	E	1	224	78	20	23	398	Double "
-+-+-	F	1	"	39	20	33	628	Single "
———	G	4	400	87	25	45	970	Double "
———	H	1	"	87	30	45	1130	" "
— — —	J	1	"	43	25	56	1275	Single "
-×-×-	K	1	"		25	87	2200	3 hand "
-+-+-	L	1	224	78	25	28	643	Double "
-+-+-	M	1	"	39	25	39	830	Single "

The stops made on descending grade of 18 feet per mile are shown graphically in the diagram on Plate No. XXXVI, and the details are set forth in Schedule No. 4.

SCHEDULE No. 4.

Stops made with American Automatic Brake on Missouri Pacific Railway, Carondelet Branch, on descending grade, 18 feet per mile.

Number of Stops.	Letter on Plate XXXVI.	Weight of Train. Tons.	Brake Used.		Initial Speed. Miles per Hour.	Speed at each 10 Seconds.								Stops Made.	
			Kind.	Per Cent. of Wheels.		10	20	30	40	50	60	70	80	Time. Seconds	Distance. Feet.
22	.....	400	Double.	87	20	14	5	..	..	..	..	..	..	23	412
24	*A*	"	"	"	20	13	1	..	..	..	..	..	..	21½	372
26	*H*	"	"	"	25	17	11	..	..	..	..	..	..	28½	580
28	*H*	"	"	"	25	19	13	..	..	..	..	..	..	31	505
30	*A*	"	"	"	20	12	..	..	..	..	..	..	..	19	326
32	*A*	"	"	"	20	13	..	..	..	..	..	..	..	18½	280
34	*A*	"	"	"	20	12	..	..	..	..	..	..	..	18	300
36	.....	"	"	"	15	9	..	..	..	..	..	..	..	18	240
38	*H*	"	"	"	25	17	11	..	..	..	..	..	..	28	575
41	*B*	"	Single.	43½	20	15	12	2	..	..	..	..	..	32½	553
43	*I*	"	"	"	25	20	14	9	..	..	..	..	..	39	768
45	*B*	"	"	"	20	16	12	5	..	..	..	..	..	35	600
47	*C*	"	Engine	& Tender.	20	17	14	11	4	..	..	..	..	48	798
50	*J*	"	Note *s*	43½	25	24	21	17	13	5	..	..	..	55	1 258
52	.....	"	" "	"	20	19	16	12	4	..	..	..	..	46	850
54	*K*	"	Hand	Note *t*	25	24	22	19	16	12	7	..	..	70	1 520
56	*D*	"	"	" "	20	19	17	14	12	8	2	..	..	70	1 205
58	*C*	"	Engine	& Tender.	20	18	16	12	8	..	..	..	..	54	938
60	Note *u*	"	Double.	87	25	21	15	8	..	..	..	..	..	36	681
62	" "	"	"	"	20	15	6	..	..	..	..	..	..	24½	395
64	.....	"	"	"	18	14	..	..	..	..	..	..	..	20	280
66	*E*	"	Note *v*	"	19	16	12	6	..	..	..	..	..	37	560
69	Note *w*	"	Double.	43	24½	18	13	..	..	..	..	..	..	30	628
71	" "	"	"	"	20	11	..	..	..	..	..	..	..	18	282
73	" " *x*	"	"	"	25	19	15	11	4	..	..	..	..	46	798
75	" "	"	"	"	20	15	11	..	..	..	..	..	..	33	570
77	" *y*	"	Single.	22	25	19	14	10	..	..	..	..	..	40	826
79	" "	"	"	"	20	15	9	..	..	..	..	..	..	29	480
81	*L z*	224	Double.	77	25	16	6	..	..	..	..	..	..	24	495
83	*F*	"	"	"	20	12	..	..	..	..	..	..	..	19	327
85	*M d*	"	"	38½	25	16	9	..	..	..	..	..	..	27	550
87	*G*	"	"	"	20	12	1	..	..	..	..	..	..	22	389

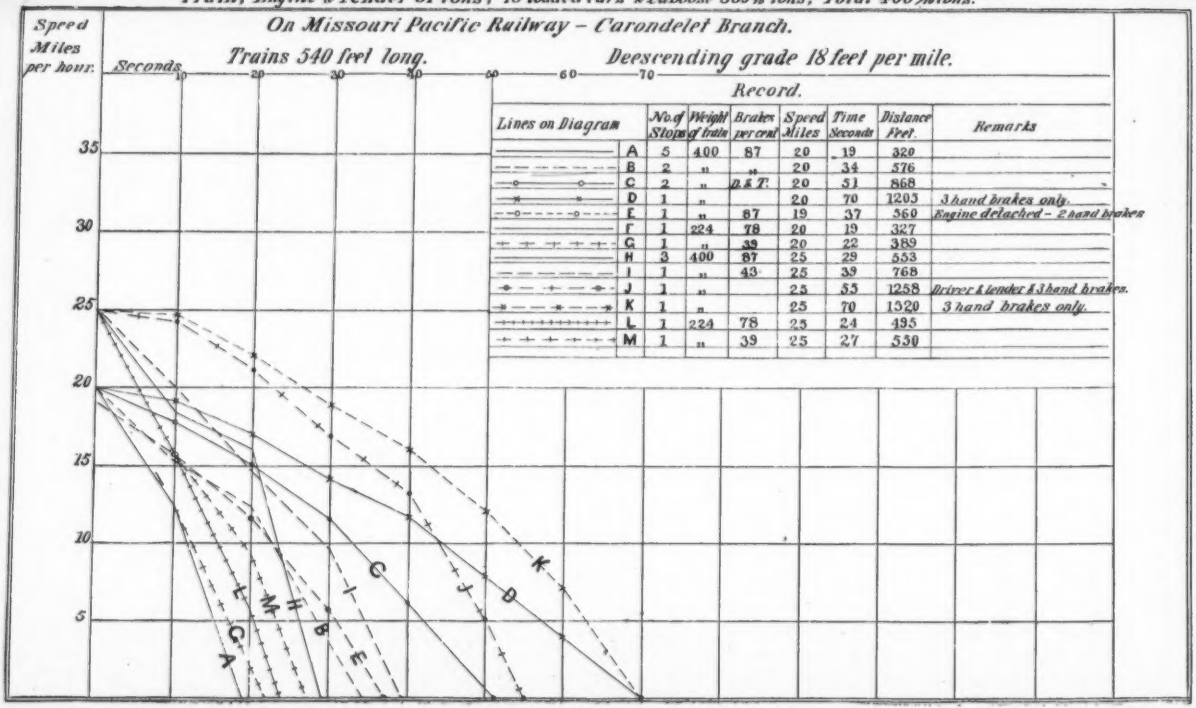
Note *s* Stops 50 and 52. Engine and tender and hand brakes only; 3 brakemen.
" *t* " 54 and 56. Used only hand brakes, set by 3 brakemen.
" *u* " 60 and 62. Engine brake applied five seconds after tender brake.
" *v* " 66. Engine detached; 2 hand brakes set, engaging automatics.
" *w* " 69 and 71. Brakes on 7 cars used; brakes on cars in rear cut off.
" *x* " 73 and 75. " " alternate cars used; balance cut out.
" *y* " 77 and 79. 1 brake on " " " " " "
" *z* " 81 and 83. 8 cars and caboose in train; 7 cars with brakes.
" *d* " 85 and 87. 8 " " " " " 7 " " 1 brake each.

Diagram of stops made by Freight Train with American Automatic Brake.

Train, Engine & Tender 61 tons; 15 loaded cars & caboose 339 7/20 tons; Total 400 7/20 tons.

On Missouri Pacific Railway – Carondelet Branch.

Trains 540 feet long. *Deescending grade 18 feet per mile.*



Record.

Lines on Diagram		No. of Stops	Weight of train	Brakes per cent	Speed Miles	Time Seconds	Distance Feet	Remarks
———	A	5	400	87	20	19	329	
– – – –	B	2	"	"	20	34	576	
○ ○	C	2	"	p. & T.	20	51	868	
× ×	D	1	"		20	70	1205	3 hand brakes only.
○ – – ○	E	1	"	87	19	37	560	Engine detached – 2 hand brakes
———	F	1	224	78	20	19	327	
+ + + +	G	1	"	39	20	22	389	
———	H	3	400	87	25	29	553	
– – – –	I	1	"	43	25	39	768	
× – × – ×	J	1	"		25	55	1258	Driver & tender & 3 hand brakes.
× – – ×	K	1	"		25	70	1520	3 hand brakes only.
+ + + + +	L	1	224	78	25	24	495	
+ – + – +	M	1	"	39	25	27	550	

SHINN ON POWER FREIGHT BRAKES.

PLATE XXXVI. TRANS. AM. SOC. CIV. ENG'RS. VOL. XIV. No. 314.

The experimental train having been run East to Boston, and being on its return, I arranged to make a second series of tests, under my personal observation, on the New York, West Shore and Buffalo Railway, and on the New York, Lake Ontario and Western Railway, the officers of which roads kindly furnished the opportunity for the use of their tracks, and on August 6th, 7th and 11th, I observed 57 test-stops, the details of which are set forth in Schedules 5, 6 and 7, and are shown graphically by the diagrams in Plates XXXVII, XXXVIII and XXXIX.

SCHEDULE No. 5.

Stops made with American Automatic Brake on New York, West Shore and Buffalo Railway.—Train, 540 feet long. Engine, 61 tons; 15 cars and caboose, $339\frac{7}{10}$. Total, $400\frac{7}{10}$ tons. Descending grades 37, 47 and $52\frac{8}{10}$ feet per mile.

Number of Stop.	Letters on Plate XXXVII.	Grade. Feet per Mile.	Brakes Used.		Initial Speed. Miles per Hour.	Speed at each 10 Seconds.								Stops Made.	
			Kind.	Per Cent. of Wheels.		10	20	30	40	50	60	70	80	Time. Seconds	Distance. Feet.
1	....	52.8	Double	87	25	..	..	..	..	..	..	..	..	....	1 496
3	....	"	"	"	25	22	19	17	15	12	8	..	..	71	1 393
4	*C*	"	"	"	16	12	8	..	..	..	..	..	..	27	321
7	*A*	"	"	"	25	19	16	13	8	..	..	..	..	49	1 027
8	....	"	"	"	16	14	12	11	10	8	7	2	..	75	1 099
11	*A*	"	"	"	25	20	16	11	1	..	..	..	..	41	839
12	*C*	"	"	"	$15\frac{1}{2}$	12	7	..	..	..	..	..	..	$25\frac{1}{2}$	301
22	*B*	"	"	"	27	24	21	18	14	9	..	..	..	58	1 263
23	*C*	"	"	"	16	12	8	..	..	..	..	..	..	30	357
57	*B*	"	"	"	26	21	17	13	8	..	..	..	..	48	854
27	*D*	"	Single	$43\frac{1}{2}$	25	23	21	20	19	18	16	15	14	126	2 540
32	*D*	"	"	"	25	22	20	18	17	15	14	12	10	105	1 950
36	*D*	"	"	"	25	22	19	17	14	12	9	2	..	79	1 433
37	*E*	"	"	"	16	14	13	11	9	5	1	..	..	61	800
16	*F*	"	Hand	Note *a*	25	25	24	23	22	20	18	15	12	95	2 322
17	*G*	"	"	" *b*	17	17	16	16	14	12	8	..	..	70	1 250
39	....	"	"	" *c*	25	24	24	23	23	21	20	18	15	106	2 710
21	*H*	37.	Note *d*	$43\frac{1}{2}$	25	24	23	21	20	19	17	15	13	123	2 560
41	*H*	"	"	"	25	24	22	20	19	17	16	14	13	122	2 290
28	*J*	47.	Single	"	15	12	10	6	1	..	..	..	..	44	472
33	*K*	"	"	"	25	23	21	19	17	15	12	8	1	81	1 686
55	....	$48\frac{4}{10}$	Double	87	27	24	21	16	13	6	..	..	..	57	1 170
56	....	$44\frac{1}{10}$	"	"	25	21	19	16	13	8	..	..	..	60	1 120

Note *a*. Stop No. 16. Hand-brakes set on signal by 3 brakemen; all set.
" *b*. " " 17. " " " " 3 " 14 brakes set.
" *c*. " " 39. " " " " conductor and one brakeman; 10 brakes set.
" *d*. " " 21 and 41. Engine and tender brakes only.

Diagram of stops made by Freight trains with American Automatic Brake.
Train 540 feet long. Engine & tender 61 tons: 15 cars & caboose 339⅞ tons: total 400⅞ tons.

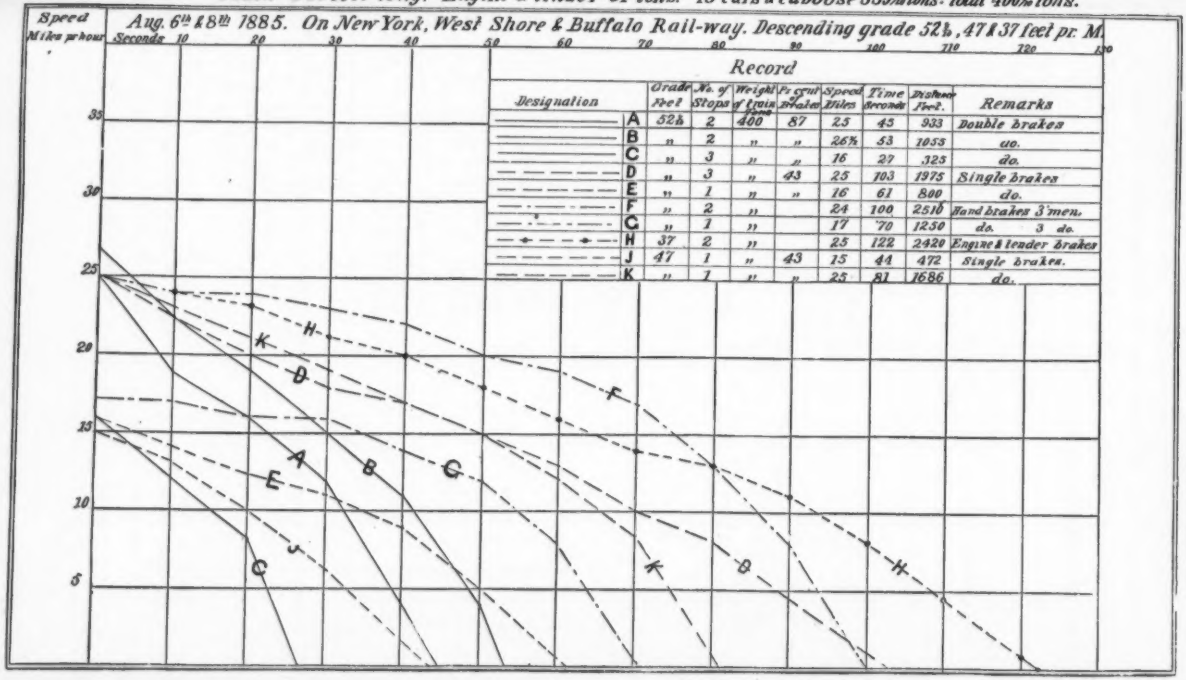

Speed
Miles per hour
Seconds
Aug. 6th & 8th 1885. On New York, West Shore & Buffalo Rail-way. Descending grade 52⅞, 47 & 37 feet pr. M.
Record
Designation
Grade Feet
No. of Stops
Weight of train
Fr. cars brakes
Speed Miles
Time Seconds
Distance Feet.
Remarks
A 52⅞ 2 400 87 25 45 933 Double brakes
B " 2 " " 26⅞ 53 1055 do.
C " 3 " " 16 27 323 do.
D " 3 " 43 25 103 1975 Single brakes
E " 1 " " 16 61 800 do.
F " 2 " 24 100 2510 Hand brakes 3 men.
G " 1 " 17 70 1250 do. 3 do.
H 37 2 " 25 122 2420 Engine & tender brakes
J 47 1 " 43 15 44 472 Single brakes.
K " 1 " " 25 81 1686 do.

PLATE XXXVII.
TRANS. AM. SOC. CIV. ENG'RS.
VOL. XIV. No. 314.

SHINN ON
POWER FREIGHT BRAKES.

This being the first opportunity for testing the brake in making stops on a level, I had 21 such stops made, the record of which is shown graphically by diagrams Plate No. XXXVIII; and full details are set forth in Schedule No. 6.

SCHEDULE No. 6.

Stops made with American Automatic Brake on New York, West Shore and Buffalo Railway. Train, 540 feet long. Engine, 61 tons; 15 cars and caboose, $339\frac{7}{10}$. Total, $400\frac{7}{10}$ tons.

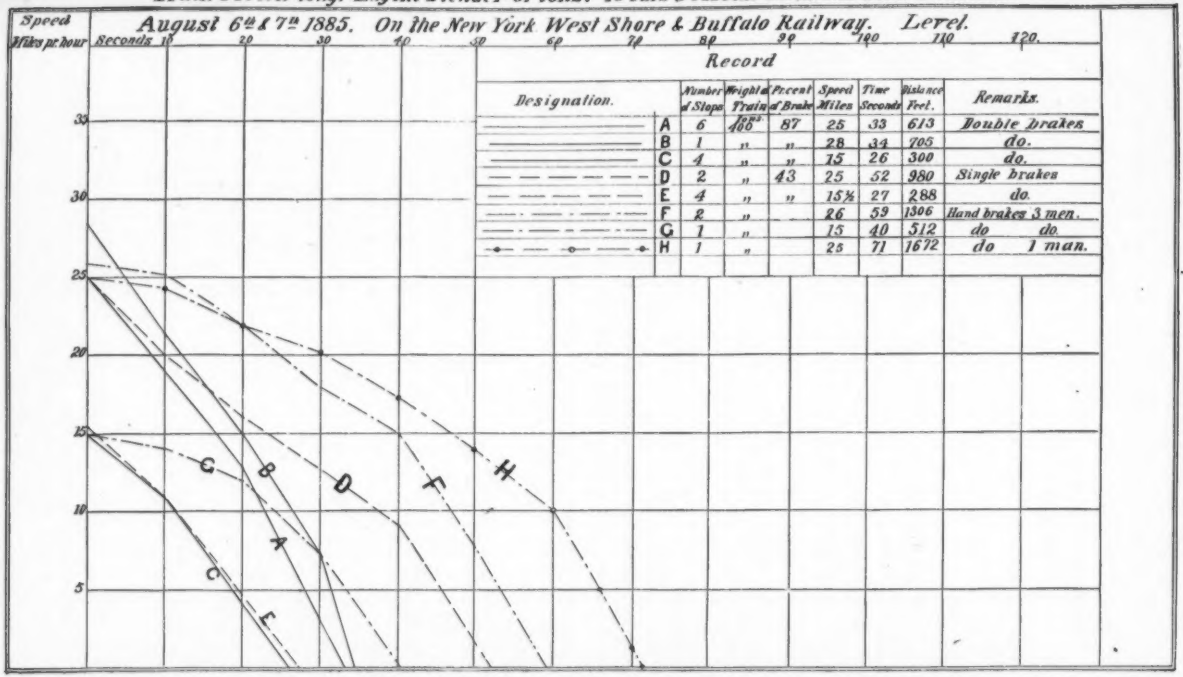
LEVEL.

Number of Stop.	Letter on Plate No. XXXVIII.	Brakes Used. Kind.	Brakes Used. Per cent. of Wheels.	Initial Speed. Miles per Hour.	Speed at each 10 Seconds. 10	20	30	40	50	60	70	80	Stops Made. Time. Seconds.	Distance. Feet.
2	*A*	Double.	87	24	19	13	4	..	..	..	..	..	34	643
5	*A*	"	"	15	19	13	..	..	..	..	..	..	31	605
6	*C*	"	"	15	11	8	..	..	..	..	..	..	30	348
9	*A*	"	"	25	18	11	..	..	..	..	..	..	27	508
10	*C*	"	"	$15\frac{1}{2}$	12	8	..	..	..	..	..	..	31	346
13	*A*	"	"	25	19	13	1	..	..	..	..	..	$31\frac{1}{2}$	586
14	*C*	"	"	15	10	1	..	..	..	..	..	..	22	254
15	*B*	"	"	28	21	15	7	..	..	..	..	..	34	705
24	*A*	"	"	25	18	13	5	..	..	..	..	..	33	582
25	*A*	"	"	25	19	15	11	..	..	..	..	..	40	753
26	*C*	"	"	15	10	1	..	..	..	..	..	..	22	....
29	*E*	Single.	$43\frac{1}{2}$	16	11	3	..	..	..	..	..	..	26	294
30	*D*	"	"	25	20	17	14	10	1	..	..	..	55	969
31	*E*	"	"	16	11	6	..	..	..	..	..	..	30	313
34	*E*	"	"	15	11	2	..	..	..	..	..	..	26	273
35	*D*	"	"	25	20	16	13	8	..	..	..	..	49	990
38	*E*	"	"	15	11	2	..	..	..	..	..	..	26	273
18	*F*	Hand.	Note *e*	24	23	21	16	13	5	..	..	..	55	1 160
19	*G*	"	" *f*	15	14	12	7	..	..	..	..	..	40	512
20	*F*	"	" *g*	28	26	24	20	16	11	2	..	..	63	1 444
40	*H*	"	" *h*	25	24	22	20	17	14	10	2	..	71	1 672

NOTE *e* Stop No. 18. Hand brakes set on signal by 3 brakemen on 12 cars and caboose.
" *f* " " 19. " " " " 3 " " 8 " "
" *g* " " 20. " " " " 3 " " 13 " "
" *h* " " 40. " " " " 1 brakeman and conductor on 7 cars and caboose.

The test stops, 13 in number, made on the Cornwall Grade (descending $79\frac{2}{10}$ feet per mile) of the New York, Ontario and Western Railway, are shown graphically by diagrams on Plate No. XXXIX, and in detail in Schedule No. 7 following.

Diagram of stops made by Freight trains with American Automatic Brake.
Train 540 feet long. Engine & tender 61 tons. 15 cars & caboose 339⅞ tons: Total 400⅞ tons.


Speed Miles pr hour
August 6th & 7th 1885. On the New York West Shore & Buffalo Railway. Level.
Seconds 10 20 30 40 50 60 70 80 90 100 110 120.
Record
Designation. | Number of Stops | Weight of Train | Percent of Brake | Speed Miles | Time Seconds | Distance Feet. | Remarks.
A | 6 | 400⅞ | 87 | 25 | 33 | 613 | Double brakes
B | 1 | " | " | 28 | 34 | 705 | do.
C | 4 | " | " | 15 | 26 | 300 | do.
D | 2 | " | 43 | 25 | 52 | 980 | Single brakes
E | 4 | " | " | 15½ | 27 | 288 | do.
F | 2 | " | | 26 | 59 | 1306 | Hand brakes 3 men.
G | 1 | " | | 15 | 40 | 512 | do do.
H | 1 | " | | 25 | 71 | 1672 | do 1 man.
35
30
25
20
15
10
5
A
B
C
D
E
F
G
H

SHINN ON POWER FREIGHT BRAKES.

PLATE XXXVIII.
TRANS. AM. SOC. CIV. ENG'RS.
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The engine used in stops Nos. 42 to 49 was the Wabash, St. Louis and Pacific Railroad engine. 8-wheel engine, 4 drivers 5 feet 6 inches diameter.

Weight on drivers	46 200 lbs.
Weight on truck	26 850 "
Total	73 050 "

While for stops Nos. 52 to 54, engine No. 58 of New York, Ontario and Western Railway was used. 10-wheel engine, 6 drivers 4 feet 6 inches diameter.

Weight on drivers	61 000 lbs.
Weight on truck	13 000 "
Total	74 000 "

SCHEDULE No. 7.

Stops made with American Automatic Brake on New York, Ontario and Western Railway.—Train, 540 feet long. Engine, 61 tons; 15 cars and caboose, $339\frac{7}{10}$ tons. Total, $400\frac{7}{10}$ tons.

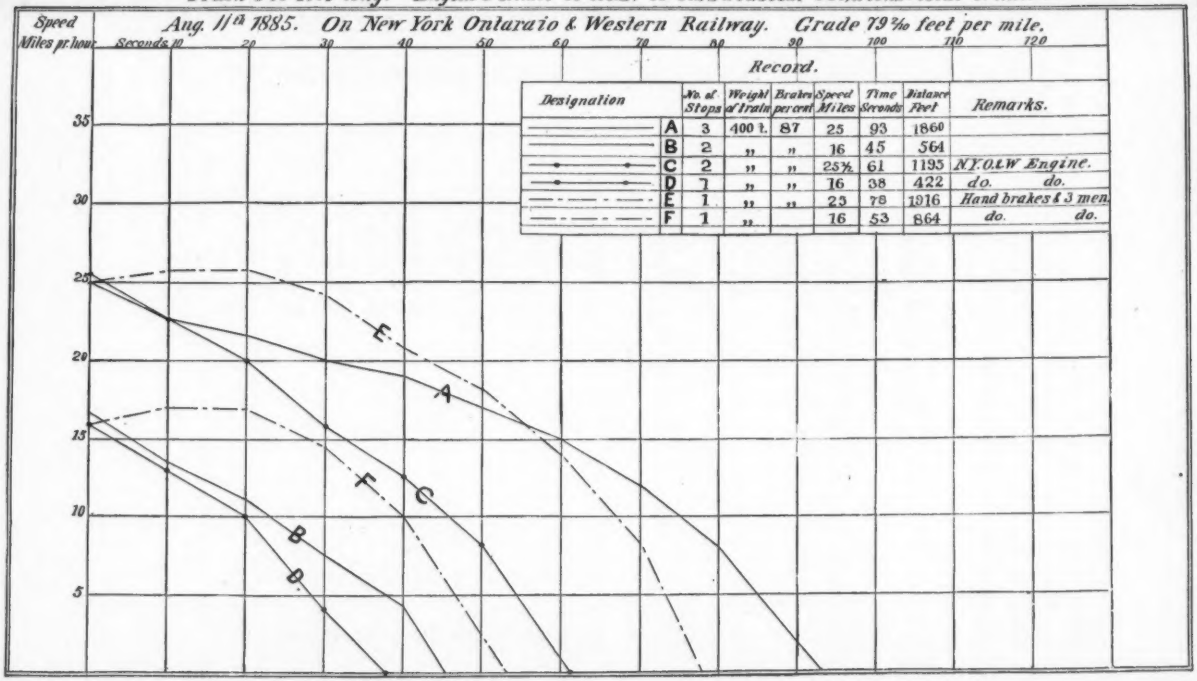
Descending grade 76.56 and 79.2 feet per mile.

Number of Stop.	Letter on Plate No. XXXIX.	Grade. Feet per Mile.	Brakes Used.		Initial Speed. Miles per Hour.	Speed at each 10 Seconds.								Stops Made.	
			Kind.	Per cent. of Wheels.		10	20	30	40	50	60	70	80	Time. Seconds	Distance. Feet.
42	*B*	$79\frac{2}{10}$	Double.	87	16	12	9	4	..	..	..	..	..	36	396
43	*B*	"	"	"	17	15	13	11	8	4	..	..	..	55	732
45	....	"	"	"	26	24	22	21	20	20	19	17	14	117	2 532
46	*A*	"	"	"	25	22	21	19	18	15	13	10	4	86	1 713
47	*A*	"	"	"	25	23	22	21	20	19	18	15	12	96	2 122
49	*A*	"	"	"	25	22	21	19	18	16	14	12	9	96	1 759
52	*D*	"	"	"	16	13	10	4	..	..	..	..	..	38	422
53	*C*	"	"	"	26	22	20	16	13	9	4	..	..	65	1 228
54	*C*	"	"	"	$25\frac{1}{2}$	22	20	16	12	7	..	..	..	57	1 160
50	*E*	"	Hand.	Note *j*	25	26	26	24	21	18	14	8	..	78	1 916
51	*F*	"	"	" *k*	16	17	17	14	10	2	..	..	..	53	864
44	....	76.56	Double.	87	26	23	20	18	16	13	6	..	..	65	1 389
48	....	"	"	"	17	14	12	8	..	..	..	..	..	40	540

Note *j* Stop 50. Hand brakes set by 3 brakemen on signal, on all cars.
" *k* " 51. " " " 3 " " " but 2 cars.

Stops Nos. 52, 53 and 54 made with New York, Ontario and Western Railroad engine equipped with their air-brake, applied on both sides of six drivers.

Diagram of stops made by Freight Trains with American Automatic Brake.
Train 540 feet long. Engine & Tender 61 tons: 15 cars & caboose 339½ tons: total 400½ tons.



Record.

Designation		No. of Stops	Weight of train	Brakes per cent	Speed Miles	Time Seconds	Distance Feet	Remarks.
———	A	3	400 t.	87	25	93	1860	
———	B	2	,,	,,	16	45	564	
- - -	C	2	,,	,,	25½	61	1195	N.Y.O.&W. Engine.
- - -	D	7	,,	,,	16	38	422	do. do.
— · — · —	E	1	,,	,,	25	78	1916	Hand brakes & 3 men.
— — —	F	1	,,		16	53	864	do. do.

SHINN ON POWER FREIGHT BRAKES.

PLATE XXXIX.
TRANS. AM. SOC. CIV. ENG'RS.
VOL. XIV. No. 314.

There were exhibitions of the train making test stops given by the officers of the American Brake Company on August 14th and 15th, on the New York, West Shore and Buffalo Railway, the record of which, in detail, as furnished me by the Vice-President of the American Brake Company, is set forth in Schedule No. 8.

SCHEDULE No. 8.

Stops made with American Automatic Brake on New York, West Shore and Buffalo Railway.—Train, 540 feet long. Weight, 358 tons.

Number of Stops.	Grade.		Brakes used.		Initial Speed. Miles per Hour.	Speed at each 10 Seconds.							Stops Made.	
	Feet pr. Mile	Kind.	Kind.	Per cent. of Wheels.		10	20	30	40	50	60	70	80	Time. Seconds	Distance. Feet.
1	....	Level.	Double.	87	21	14	8	..	..	..	..	..	..	25	374
5	....	"	"	"	25	19	15	70	..	..	..	..	..	39	618
7	....	"	"	"	20	14	7	..	..	..	..	..	..	28	473
10	....	"	"	"	20	13	..	..	..	..	..	..	..	20	319
11	....	"	"	"	30	21	15	6	..	..	..	..	..	33	713
13	....	"	"	"	20	12	4	..	..	..	..	..	..	23	348
17	....	"	"	"	25	16	10	..	..	..	..	..	..	28	505
19	....	"	"	"	25	18	12	..	..	..	..	..	..	30	532
21	....	"	"	"	20	13	6	..	..	..	..	..	..	24	350
22	....	"	"	"	22½	16	9	..	..	..	..	..	..	28	440
6	21.12	Desc'g.	"	"	20	15	10	..	..	..	..	..	..	27	360
18	"	"	"	"	25	19	15	9	..	..	..	..	..	38	688
20	"	"	"	"	20	13	7	..	..	..	..	..	..	25	362
2	26.40	"	"	"	25	19	14	6	..	..	..	..	..	37	666
14	"	"	"	"	25	19	14	3	..	..	..	..	..	35	637
12	36.96	"	"	"	26	17	14	9	..	..	..	..	..	47	974
23	"	"	"	"	25½	20	16	12	5	..	..	..	..	44	840
4	47.52	"	"	"	25	19	17	14	10	..	..	..	..	50	953
9	"	"	"	"	20	16	14	6	..	..	..	..	..	36	619
16	"	"	"	"	25	21	17	14	8	..	..	..	..	48	918
3	52.80	"	"	"	25	20	16	13	8	..	..	..	..	45	878
8	"	"	"	"	20	..	..	..	..	..	..	..	..	38	623
15	"	"	"	"	25	21	18	14	8	..	..	..	..	46	909

The officers of the American Brake Company have furnished me also with the record of 23 stops made August 17th and 18th, which are of interest mainly on account of the high speed. The details form Schedule No. 9, and are shown graphically by the diagrams in Plate No. XL.

SCHEDULE No. 9.

Stops made with American Automatic Brake on Lehigh Valley Railroad. —Train: Engine; 14 cars with brakes; 3 cars without brakes. Length, 619 feet. Weight, 373 tons.

Number of Stop.	Letter on Plate XL.	Grade. Feet per mile.	Brakes Used.		Initial Speed. Miles per Hour.	Speed each 10 Seconds.								Stops Made.	
			Kind.	Per cent. of Wheels.		10	20	30	40	50	60	70	80	Time. Seconds	Distance. Feet.
		Desc'g.													
17	*A*	47	Double.	87	40	..	..	..	..	..	..	..	..	82	2 510
18	*A*	"	"	"	40	..	..	..	..	..	..	..	..	86	2 752
16	*B*	42	"	"	40	..	..	..	..	..	..	..	..	72	2 350
8	*C*	22	"	"	40	34	29	25	18	11	..	..	..	58	1 647
19	*C*	"	"	"	40	..	..	..	..	..	..	..	..	55	1 613
20	*C*	"	"	"	40	..	..	..	..	..	..	..	..	48½	1 393
21	*C*	"	"	"	40	..	..	..	..	..	..	..	..	54	1 506
22	*C*	"	"	"	40	..	..	..	..	..	..	..	..	45	1 288
23	*C*	"	"	"	40	..	..	..	..	..	..	..	..	47	1 364
9	*D*	"	"	"	25	17	9	..	..	..	..	..	..	25	450
10	*E*	"	"	"	21½	13	..	..	..	..	..	..	..	19	290
2	*H*	4½	"	"	40	32	26	20	13	..	..	..	..	48	1 310
3	*H*	"	"	"	40	33	26	20	12	..	..	..	..	48	1 332
1	*J*	"	"	"	32	26	19	12	..	..	..	..	..	39	950
5	*F*	Level.	"	"	40	32	26	19	11	..	..	..	..	47	1 379
6	*G*	"	"	"	34	29	20	10	..	..	..	..	..	33	812
7	Note.	"	"	"	36½	29	23	17	..	..	..	..	..	43	1 173
		Asc'g.													
13	.....	12	"	"	25	..	..	..	..	..	..	..	..	30	534
11	*K.*	22	"	"	27	..	..	..	..	..	..	..	..	25	470
12	"	"	"	"	25	..	..	..	..	..	..	..	..	26	488
14	"	"	"	"	25	..	..	..	..	..	..	..	..	30	491
15	.....	"	"	"	30	..	..	..	..	..	..	..	..	30	608
4	.....	26	"	"	36	27	18	8	..	..	..	..	..	33½	862

NOTE.—Stop No. 7 was made with the brake "cut out" on the nine cars in rear. See strain diagram of this stop, line *G*, Plate XLII.

Speed each 10 seconds was taken in stops Nos. 1 to 10 only.

The observations of the working of the brakes during the tests heretofore enumerated, suggested to the officers of the American Brake Company some improvements in the details, which were made after the return of the train to St. Louis. The following is the record furnished me of stops made on September 3d and 5th, shown graphically by diagrams in Plate No. XLI.

SCHEDULE No. 10.

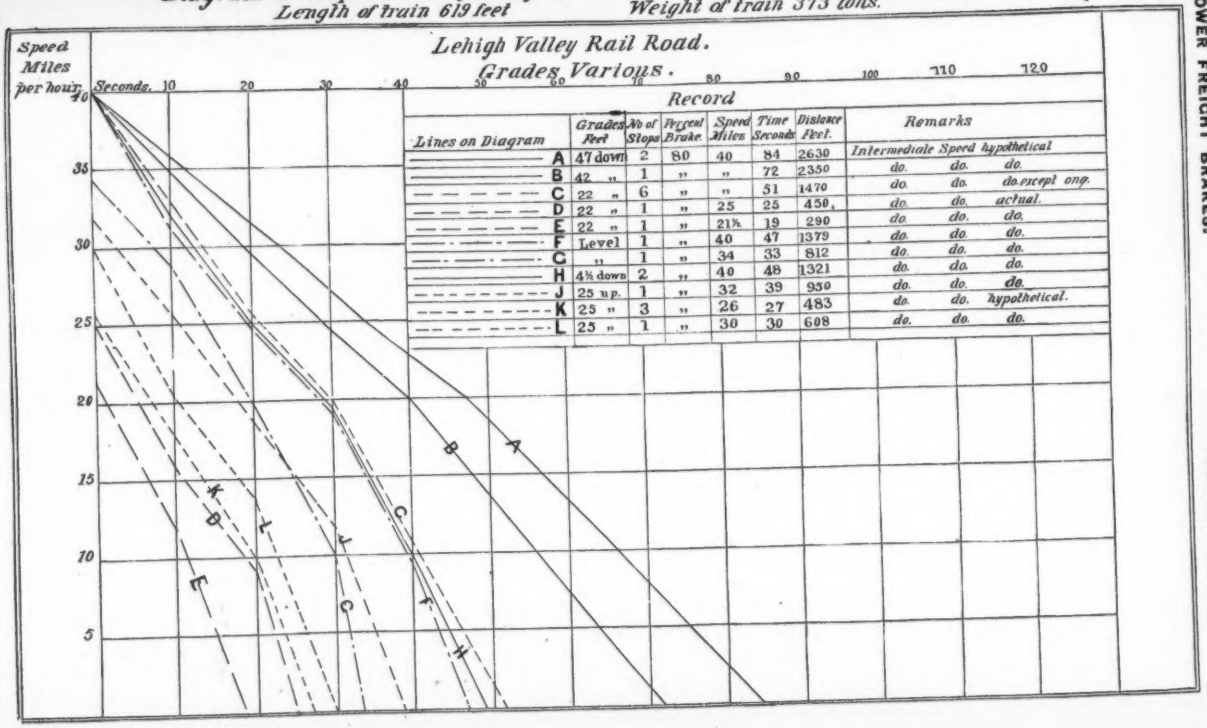
Stops made with American Automatic Brake on Missouri Pacific Railway September 4th and 5th, 1885. Train: Engine; 14 cars with brakes; 2 cars no brakes. Length of train, 600 feet. Weight, 330 tons.

Number of Stop.	Letter on Plate XLI.	Grade. Feet per Mile.	Brakes Used.		Initial Speed. Miles per Hour.	Speed each 10 Seconds.								Stops Made.	
			Kind.	Per Cent. of Wheels.		10	20	30	40	50	60	70	80	Time. Seconds	Distance. Feet
		Down.													
4	*A*	53	Double.	87	25	19	15	10	..	..	..	..	..	39	822
6	*A*	"	"	"	25	19	14	10	..	..	..	..	..	38	790
8	*B*	"	"	"	30	24	19	13	6	..	..	..	..	43½	1 100
13	....	"	"	"	23	..	..	..	..	..	..	..	..	27	567
2	*C*	"	"	"	20	15	12	4	..	..	..	..	..	32	576
10	*C*	"	"	"	20	15	10	..	..	..	..	..	..	30	514
11	*C*	"	"	"	20	13	7	..	..	..	..	..	..	25½	438
15	*E*	"	"	"	27	..	..	..	..	..	..	..	..	29	752
18	*D*	"	"	"	20	..	..	..	..	..	..	..	..	22½	410
21	*F*	"	Hand.	Note.	27	..	..	..	..	..	..	..	..	76	2 150
14	....	57	Double.	87	33	..	..	..	..	..	..	..	..	48½	1 412
16	....	21	"	"	31	..	..	..	..	..	..	..	..	35	944
19	....	"	"	"	20	..	..	..	..	..	..	..	..	19	314
1	....	18	"	"	20	15	9	..	..	..	..	..	..	29	500
3	*G*	"	"	"	25	..	..	..	..	..	..	..	..	30	500
5	*G*	"	"	"	25	17	10	..	..	..	..	..	..	26	536
7	*J*	"	"	"	30	21	14	3	..	..	..	..	..	32	685
9	*K*	"	"	"	33	22	16	9	..	..	..	..	..	37	887
20	....	"	"	"	20	..	..	..	..	..	..	..	..	17	323
12	....	Level.	"	"	20	12	..	..	..	..	..	..	..	21	328
17	....	....	"	"	19	..	..	..	..	..	..	..	..	18	337
22	*L*	....	Hand.	Note.	24	..	..	..	..	..	..	..	..	47	1 156
23	*M*	....	Double.	87	24	..	..	..	..	..	..	..	..	23½	501

Note.—Stops 13 to 23 made after omitting relief-spring on automatic brake. Stops 21 and 22 made with 14 hand brakes set on signal. Speed each ten seconds not reported on stops 13 to 23 made September 5th.

Diagram of stops made by Freight Trains with American Automatic Brake.

Length of train 619 feet *Weight of train 373 tons.*



Record

Lines on Diagram	Grades Feet	No of Stops	Percent Brake	Speed Miles	Time Seconds	Distance Feet	Remarks
A	47 down	2	80	40	84	2630	Intermediate Speed hypothetical
B	42 „	1	„	„	72	2350	do. do. do.
C	22 „	6	„	„	51	1470	do. do. do. except one.
D	22 „	1	„	25	25	450	do. do. actual.
E	22 „	1	„	21¼	19	290	do. do. do.
F	Level	1	„	40	47	1379	do. do. do.
G	„	1	„	34	33	812	do. do. do.
H	4½ down	2	„	40	48	1321	do. do. do.
J	25 up.	1	„	32	39	930	do. do. do.
K	25 „	3	„	26	27	483	do. do. hypothetical.
L	25 „	1	„	30	30	608	do. do. do.

PLATE. XL
TRANS. AM. SOC. CIV. ENG'RS.
VOL. XIV. No. 314.

It is greatly to be regretted that my data in regard to stops made with the Westinghouse automatic brake are so meager, and, in what I have, the time consumed in making stops and the distance run do not always agree; as in stop *N*, Schedule No. 1, where, at the initial speed of 30 miles per hour (44 feet per second), the train would run in 20 seconds but 880 feet, while it is claimed to have run 975 feet in 20 seconds and come to a stop. I will assume the distances run to be more nearly correct in making my comparisons, although the diagrams (Plate No. XXXIV) are based on the assumption that the time is correct and the reduction of speed uniform.

Comparing stop *D* (Schedule No. 1) with stop *C* on same grade, it seems that the Westinghouse automatic stops the train more quickly without the engine than with it. This is what might be expected, owing to the greater momentum of the engine. There are but few of the stops that can be compared with those made by the American brake, of which the following are the best examples, viz.:

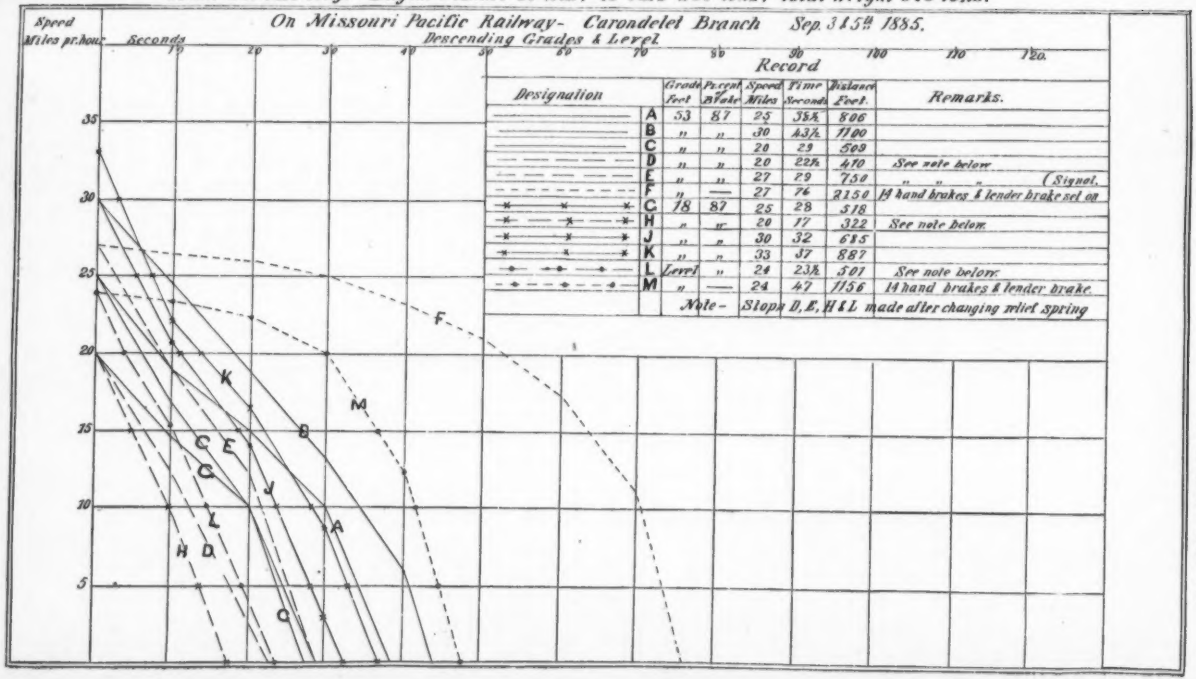
Systems.	Stops.		Grade Feet per Mile.	Speed Miles per Hour.	Distance Feet.	Remarks.
	Schedule.	No.				
Westinghouse...	No. 1	*F*	Level.	24.5	420	Engine detached.
American.....	" 6	9	do	25	508	" attached.
Westinghouse ..	" 1	*P*	do	35	630	Loaded cars.
American.....	" 9	6	do	34	812	" "
Westinghouse ..	" 1	*H*	53 feet	30	630	Empty "
American.....	" 3	7	do	32	1 038	" "

These few comparisons seem to indicate that the American brake approaches the Westinghouse in efficiency very closely on a level, but that the latter is the more efficient on descending gradients, and the steeper the descent the more favorable to the Westinghouse is the comparison.

Comparing stops *A* and *F*, Schedule No. 1, it appears that at almost identical initial speed with the same train, it required 420 feet on a level and but 784 feet on a descending grade of 116 feet per mile to make a

Diagram of stops made by Freight train with American Automatic Brake.

Train 540 feet long. Engine & Tender 61 tons; 16 cars 284 tons; total weight 345 tons.



On Missouri Pacific Railway- Carondelet Branch Sep. 31st 1885.

Descending Grades & Level.

Record

Designation		Grade Feet	Percent of Grade	Speed Miles	Time Seconds	Distance Feet	Remarks.
———	A	53	87	25	38½	806	
———	B	"	"	30	43½	1190	
———	C	"	"	20	29	509	
———	D	"	"	20	22½	410	See note below.
———	E	"	"	27	29	750	" " " (Signal.
———	F	"	—	27	74	2150	½ hand brakes & Tender brake set on
× × ×	G	78	87	25	28	518	
× — × — ×	H	"	"	20	17	322	See note below.
× × ×	J	"	"	30	32	685	
× — × — ×	K	"	"	33	37	887	
• — • — •	L	Level	"	24	23½	501	See note below.
• — • — •	M	"	—	24	47	1156	½ hand brakes & Tender brake.

Note- Stops D, E, H & L made after changing relief spring

PLATE XLI.
TRANS. AM. SOC. CIV. ENG'RS.
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stop. This is very creditable to the Westinghouse brake, and justifies its use on heavy grades approximating two per cent. and upwards.

There is much to be learned by a careful study of the Schedules Nos. 2 to 10, and the Diagram Plates Nos. XXXV to XLI. I will point out a few of the most important features, and leave the remainder to be studied by those interested.

On Plate No. XXXV, lines *E*, *F*, *L* and *M* show the advantage in the resistance offered by the engine with steam brake to the light (unloaded) train. Compare *E* and *F* with *A* and *B*, the latter being the diagrams with loaded train, also *L* and *M* with *G* and *J*. Compare diagram lines *G*, *C* and *K*, all being stops made with same train on 53 feet descending grade at 25 miles per hour:

G—45 seconds, 970 feet with double automatic and engine brakes.
C—93 " 1 630 " " engine and tender brake only.
K—87 " 2 200 " " 3 brakemen setting hand brakes on signal. The brakemen were out on the train and watching for signal.

Schedule No. 4 and Plate No. XXXVI show some excellent stops made on descending 18 feet per mile gradient at the speed of 20 and 25 miles per hour.

Compare stops Nos. 50 (*J*), 54 (*K*) and 28 (*H*), all made on 18 feet grade at 25 miles per hour.

No. 50. Line *J*—55 sec., 1 258 ft. Engine brake and hand brakes set by 3 brakemen.
No. 54. " *K*—70 " 1 520 " Hand brakes only, 3 brakemen.
No. 28. " *H*—31 " 505 " Double automatic brakes.

The engine and tender brake saves 262 feet over the hand brakes alone, while the automatic stops the train in one-third the distance required by hand brakes alone.

Schedule No. 5 and diagram Plate XXXVII, Line *F*, shows a typical stop with hand brakes, set by 3 good brakemen ready for the signal. Compare this with line *A* at slightly higher speed (25 miles), and note that when time had elapsed equal to that required for stops with automatic brakes (45 seconds), the speed had been reduced by hand brakes only from 24 to about 21 miles per hour. It is the prompt action of the automatic brakes, reducing speed 5 to 7 miles per hour in the first 10 seconds, that proves their superiority over hand brakes.

Line *H* shows that the engine and tender brake alone reduces speed more rapidly during the first 30 to 50 seconds than hand brakes set by 3

good brakemen standing ready for signal. A comparison of the results with single and double brakes shows the latter to be nearly twice as efficient as the former.

Schedule No. 6 and diagrams Plate No. XXXVIII show a fair comparison of the efficiency on a level track of double, single and hand brakes. At 25 miles per hour the showing is:

With double automatic, stop made in..... 613 feet.
" single " " " " ..... 980 "
" hand brakes, 3 men," " " ".....1 306 "

While at 15 miles per hour the comparison is:

With double automatic, stop made in..... 254 feet.
" single " " " " ..... 273 "
" hand brakes, 3 men, " " " ..... 512 "

Schedule No. 7 and diagrams Plate No. XXXIX show the only stops made on one and a half per cent. grade (79.2 feet per mile). The stops with automatic brakes show much more favorably with the New York, Ontario and Western Railway engine—not, as I believe, in consequence of its having a better driver-brake, but because it had more weight on drivers and less diameter of drivers, giving more tractive power, it being the class of engine required to handle such a train on that grade.

Compare lines *C* and *E*, at speed of 25 miles per hour, as follows:

Line *C*, with double automatic, stop made in ..... 1 195 feet.
" *E* " hand brakes, 3 men, " " " ..... 1 916 "

Also compare lines *D* and *F*, at speed of 15 miles per hour:

Line *D*, with double automatic, stop made in ..... 422 feet.
" *F* " hand brakes, 3 men, " " " ..... 864 "

It is to be noted that the brakemen were so active, that in stop *E* all hand brakes were set, and in stop *F* all but two were set.

Schedule No. 8 calls for no special comparisons, the stops having all been made with the double automatic brakes.

Schedule No. 9 and diagrams Plate No. XL, make an interesting exhibit of stops made at high speed; lines *A*, *B*, *C* and *F* showing stops made at initial speed of 40 miles an hour, as follows:

Line *A* on descending 47 ft. grade in .....2 630 feet.
" *B* " " 42 " " " .....2 350 "
" *C* " " 22 " " " .....1 470 "
" *F* " level " .....1 379 "

the comparison being interesting, at least.

The lines *J*, *K* and *L* of stops made on ascending 25 feet grade are also of interest.

Schedule No. 10 and diagrams Plate No. XLI are chiefly noticeable for the comparison of automatic with hand-brake stops, which shows as follows:

Line	*E*,	speed 27 miles,	grade 53 ft.,	automatic brakes,	in	752	feet.
"	*F*	" 27 "	" 53 "	hand brakes,	"	2 150	" .
"	*L*	" 24 "	level	automatic brakes,	"	501	"
"	*M*	" 24 "	"	hand brakes,	"	1 156	"

The hand brakes were set on tender and 14 cars by fireman, conductor and 3 brakemen, and show nearly 3 to 1 in favor of automatic brakes on 53 feet grade, and over 2 to 1 on the level. A comparison of the diagram lines will show that when *E*, with automatic brakes, had time to stop, *F*, with hand brakes, had reduced speed only 2 miles per hour; and that when *L*, with automatic brakes, had time to stop, *M*, with hand brakes, had reduced speed less than 3 miles per hour.

The rapid reduction of speed is of the greatest importance, for the damage, in case of collision or obstruction, is dependent on the momentum, which is as the square of the speed.

It should here be noted that in all my experiments with the American brake, no factitious aids were allowed; I did not even allow the engineer to use sand, and care was taken to preserve actual working conditions as nearly as possible. On the contrary, all the stops made with the hand brakes were made especially favorable to that system. The brakemen were out on the train, expecting the signal to stop, and were anxious to "make a record" for themselves and the hand brakes. In practical railroad work the brakemen are usually on the engine and in the caboose, and, in case of impending collision or other accident, the time lost in getting to where they can set the first brake often permits the train to run so far as to strike. This is the special advantage of a driver and tender brake, that it is set in an instant after steam is shut off, and as General Manager Thomas, of the Cleveland, Columbus, Cincinnati and Indianapolis Railroad, says: "In case of emergency they are better than any two brakemen that can be gotten on top of a freight train."

Another great advantage of a driver and tender brake is in its use in stopping at stations and water plugs, avoiding the use of the reverse lever, which is so injurious to live stock in the trains, and causes

much damage to other freight and particularly to the draw-heads of cars; in these respects alone it will save yearly many times its annual cost.

Plate No. XLII is an exact reproduction of eight of the automatic diagrams taken by the apparatus in the gauge car, showing the strain on the pull-rod of the brake during the entire period covered by each of the stops indicated in the diagrams. The following statement shows the stops, in making which these diagrams were made, and further details in regard to them will be found by reference to the schedules of stops and the diagrams of speed during stops.

DATA OF STOPS COVERED BY STRAIN DIAGRAMS, PLATE XLII.

Road Stops Made on	Refer to		Diagram Letter, Plate XLII.	Grade. +Up. −Down.	Speed. Miles per Hour.	Stops Made.		Remarks.
	Schedule No.	Stop No.				Time, Seconds.	Distance, Feet.	
N. Y., W. S. & B..	5	11	*A*	−52.8	25	41½	839	Gauge car in center.
N. Y. & N. E.....	..	....	*B*	−36	30	47½	1088	" " " front.
do	..	....	*C*	+47.5	24	15	349	" " " "
Lehigh Valley....	9	9	*D*	−22	25	25	450	" " " "
do	"	8	*E*	−22	40	58	1647	" " " "
do	"	10	*F*	−22	21½	19	290	" " " "
do	"	7	*G*	Level	36½	43	1173	9 cars, no brakes.
do	"	4	*H*	+26	36	33½	862	

In the plate there are three base lines, the upper being for diagrams A, B and C; the middle base line for diagrams D and E (the two lines marked E constituting a diagram of the same stop; the more irregular indicating the first, and the more nearly horizontal line indicating the last half of the stop); the lower base line applies to the diagram lines F, G and H.

The short vertical lines on this diagram represent time spaces of two and one-half seconds each. The figures at the right indicate the strain in pounds, and where there are two sets on the same line, the larger refers to the second base line below.

As before stated, some of the stops were made with the gauge car in the middle of the train, which gave a diagram presumably indicating the average strain on the pull-rod, from which could be calculated the average pressure on the brake. The diagram, line A, is the only one of this character shown in the plate, and it is entirely typical of the diagram made while the gauge car was in that position.

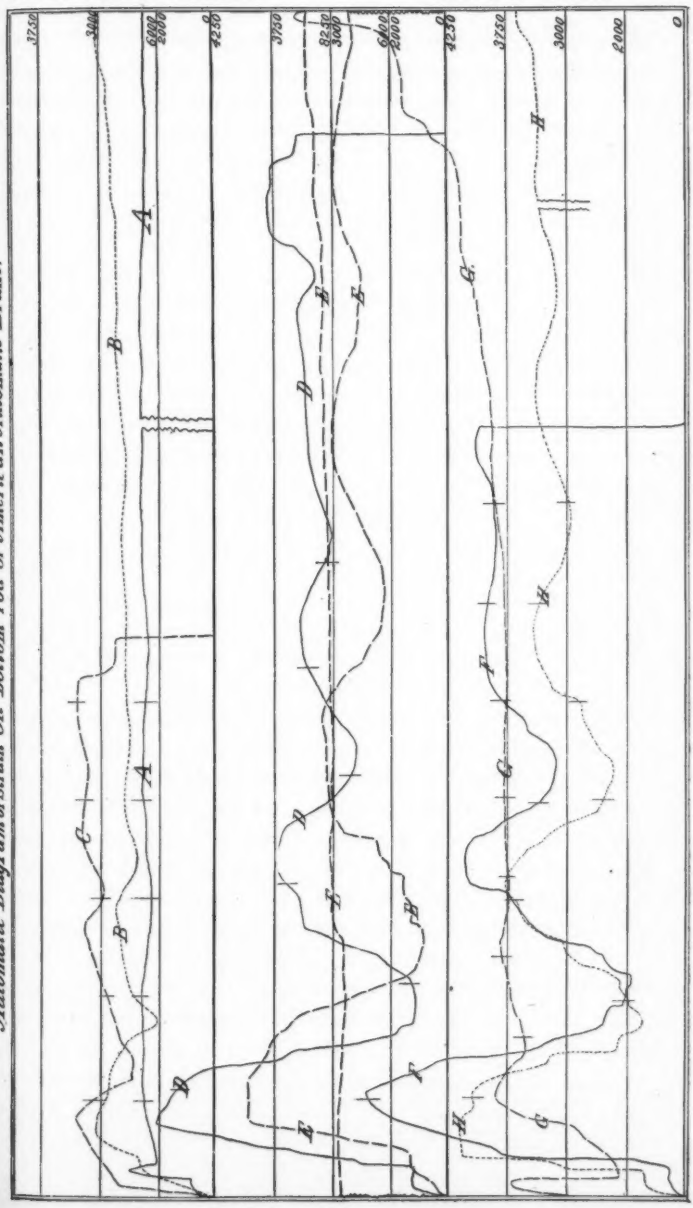
The remainder of the strain diagrams shown in the plate were made with the gauge car next to the tender, which gives the maximum of strain with a train of the weight experimented upon, and under the conditions in which the several stops were made. Attention is called to the prominent features, viz.:

First.—To the sharpness of the diagram, indicating the maximum of strain at the beginning of each stop produced by the suddenly arrested momentum of the train when the driver-brake is put on.

Second.—To the recession of the strain to the minimum immediately following the first impact, caused by the reaction of the train after its momentum had been so suddenly arrested.

Third.—To the second reaction, giving a strain equal to about two-thirds of that of the first impact, followed by a third reaction, showing a reduction of the strain to one-half as much below the average as the preceding wave had been above it. These waves of strain are all found to have occurred within the first ten to fifteen seconds. The maximum and minimum generally take place during the first five seconds, and the next superior and inferior wave within the ensuing seven seconds, so that after fifteen seconds the strain becomes reasonably uniform.

Fourth.—Contrary to the opinion of the Brake Company, as expressed in the quotation made from their catalogue, that "the amount of braking pressure diminishes as the speed of the car is checked," the diagrams show that the amount of braking pressure remains measurably constant to the very end of the stop, the end of the diagram being in nearly every case a practically perpendicular line, as shown plainly in the ends of diagrams D and F. This does not, however, appear to result in "skidding," or sliding the wheels. This is doubtless due, in a great measure, to the moderate pressure on each wheel, and it is partly due to what was noticed by Captain Douglas Galton in his paper "On the Effect of Brakes on Railway Trains," read by him before the Institution of Mechanical Engineers (*Engineering*, May 2, 1879, pp. 371–373), and was called by him "The decrease in the co-efficient of friction aris-



Automatic Diagram of strain on bottom rod of American Automatic Brake.

ing from time," which, as he says, "results from the time during which they are kept applied, irrespective of any change in speed."* This decrease in the co-efficient of friction, while the pressure remains constant, must result from some change in the physical conditions, and is probably due to the heating of the brake-shoes, and of the wheels or tyres, caused by the friction and developed by its continuance. Under some circumstances the pressure rises at the end of the stop, as is illustrated in a remarkable manner by the diagram line G, where the strain during the last ten seconds ran up from 4 250 pounds to about 9 000 pounds. This was caused by the fact that the train, which consisted of 17 cars, had 7 cars in front to which brakes were applied, behind which were 9 cars without brakes. The momentum of these 9 cars caused the increase in pressure indicated.

It appears that when all the cars are supplied with brakes, the strain upon the brakes is almost uniform after the first fifteen seconds of the stop, and this appears to be the case without particular regard to the grade or speed. The short wave at the beginning of each diagram, before the principal strain begins, is evidently caused by the shutting off of steam from the engine previous to the application of the driver-brake, and it shows that the mere act of shutting off steam will bring a strain upon the brake-rods of about 1 000 pounds, equivalent to a pressure upon the brakes of 2 000 and 3 000 pounds respectively for the wheels of each truck. The diagram, line A, indicates that on a 52.8-grade, at a speed of 25 miles an hour, with a train of 400 tons in weight, the weight of engine being 61 tons, the average strain on the brake-rod after the first five seconds of stop will be about 2 500 pounds, and the pressure of the brakes upon the wheels will be 5 000 and 7 500 pounds respectively, being greater than this at the front and less at the rear of the train. It is believed by the writer that (the gradient and speed remaining the same) this average pressure will be increased by additions to the length of the train, as, where the brakes are applied to all the cars, the momentum of each car seems to be measurably taken care of by its own brakes, so that while the momentum does not become cumulative to the extent that would naturally have been expected, the brake will be proportionately more effective on long trains.

* Valuable information regarding the action and effect of brakes (particularly of continuous brakes) on railway trains, can be had from the three papers read by Captain Galton before the Institute of Mechanical Engineers, and published in Engineering for June 14th, 1878, November 15th, 1878, and May 2d, 1879, giving the results of his trials and experiments with the Westinghouse automatic brakes on passenger trains in England.

Plate No. XLIII shows the diagram of pressure upon the draw-bar made in a single stop, all the lines of the diagram being parts of one diagram, lines B, C and D being continuations of line A. In this diagram the perpendicular lines represent seconds of time, and the horizontal lines represent degrees of pressure, indicated by the figures at the left of the plate, the values of the lines being given from base line of diagram A, and each succeeding diagram being moved up by one line; the values for the lines B, C and D should be taken from their respective base lines. It will be seen that the maximum pressure was reached between the second and third seconds, and amounted to 25 000 pounds, while between the fifth and sixth seconds the pressure receded to about 6 000 pounds, followed by an upward wave, which, at the eighth second, reached nearly 20 000 pounds, and between the tenth and eleventh reached about 22 000 pounds, the second downward reaction being at its minimum at the twelfth second, when the pressure was reduced to 8 700 pounds, followed at the thirteenth second by an upward wave reaching almost 20 000 pounds, after which the strain was reasonably constant at about 18 000 pounds, until within ten seconds of the completion of the stop, when it began to increase and reached its last maximum five seconds before the completion of the stop at about 22 000 pounds. There is a curious succession of waves about once in each second, but it will be noticed by comparing this Plate with Plate No. XLII, that these waves are all absorbed by the draw-bar springs, and do not appear in the diagrams of strain on the pull-rod. This diagram of Plate No. XLIII is entirely typical, for which reason I have thought it unnecessary to reproduce more than one. These diagrams are very instructive, and they have already indicated to the company where changes can be made that will add to the efficiency of their brake. Although the pressure upon the brakes remains so nearly constant to the end of the stop, the diagrams show, contrary to general expectations, that the brake releases with absolute promptness as soon as the motion of the train actually ceases; that it does not require the engine to be moved forward to draw out the draw-bars sufficiently to allow the push-bars to rise and the brakes to slacken. During the experiments which I witnessed, the train was backed several times without taking slack in order to relieve the brakes. This I regard as a very important feature, and it is contrary to what was generally expected.

The question of cost of power brakes, and of their maintenance, is a

very essential one to be considered in any discussion of the question. The cost of the Westinghouse brake as given in the company's catalogue, and which covers all the apparatus applied to the car, is $50 at the works of the company; the cost of attaching it to the car is $6.50 per car, making the total cost per car $56.50, and in addition the freight on the materials from the works of the company. This is for a brake applied to both trucks of a car, the company in its catalogue recommending that the brakes should in all cases be applied to both trucks of each car. To this recommendation I most cordially assent, as the old plan of brakes upon one truck of each car entirely fails to meet the necessities of the present conditions of the service, with the increased weight of cars and increased length of trains. On the question of cost of maintenance of the Westinghouse brake the data are very meager. An English publication handed me by the secretary of the company, gives the cost of repairing and maintenance of Westinghouse brakes and machinery for the two years 1882 and 1883 (the number of vehicles being 2 666, these being passenger equipment) as 9s. 5.35d., equal to about $2.27 per year. The cost of the air-pump, driver-brake and other apparatus applied to the engine in the Westinghouse system, is given in their catalogue as $360 for the materials at the company's works, the cost of applying the same to the engine being $50, making the total cost per engine $410, with the freight from the company's works in addition.* Of the cost of maintenance of the engine apparatus I have no information at present.

The cost of the driver and tender brake of the American Brake Company is, for all the materials at the company's works, $200. The cost of its application to an engine and tender is stated by the company to be $25, making the total cost per engine $225, in addition to the freight from the company's works. The cost of the apparatus constituting the American automatic brake applied to each freight car is as follows:

For a single truck—Materials	$15 00	
Application—New car 75 cents, old car	1 50	
		$16 50
For both trucks—Materials	25 00	
Application—New car $1.50, old car	3 00	
		$28 00

*This does not include the driver-brake itself, nor its connections with the engine and piston rods of air cylinders, estimated at $90. These parts are included in the price named for the American driver-brake.

Automatic Diagram of Compression of Drawbar Spring in experiments with the American Automatic Brake.

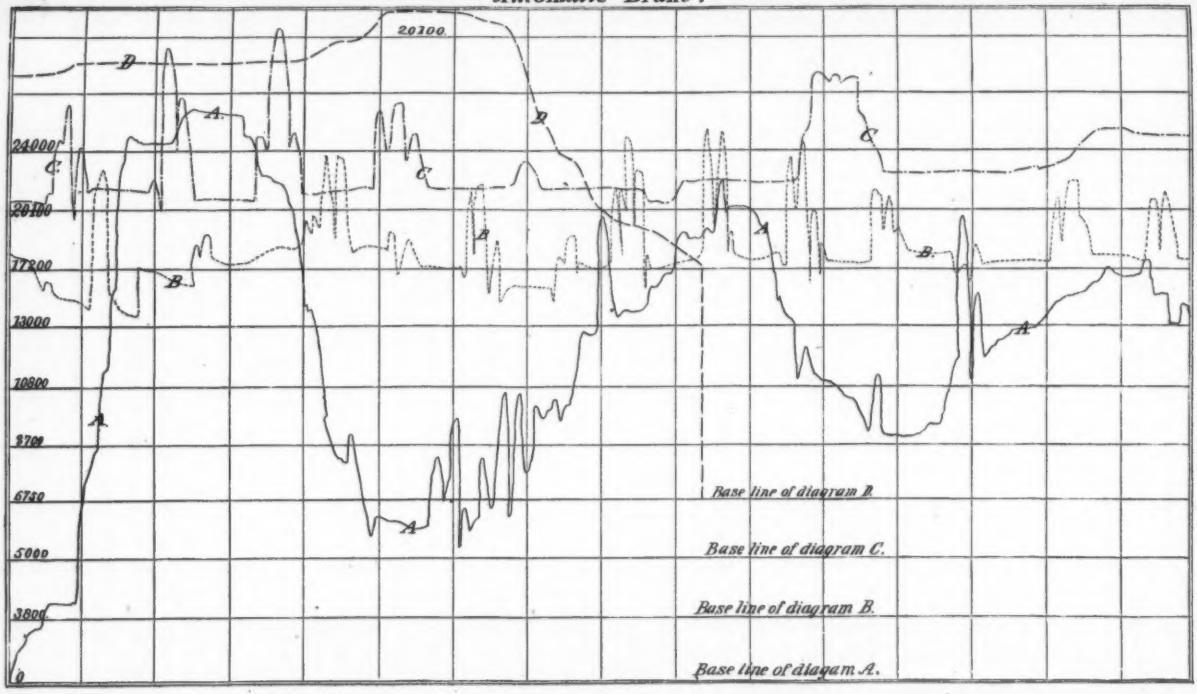


PLATE XLIII.
TRANS. AM. SOC. CIV. ENG'RS.
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SHINN ON
POWER FREIGHT BRAKES.

to which the freight from the company's works is to be added. The officers of the company inform me that they will guarantee that the cost of maintenance of the driver and tender brake shall not exceed $10 per year, unless in case of the engine being wrecked; and under like conditions the cost of maintenance per car per year for a single brake shall not exceed $1, and for the double brake $2. These figures are for the materials furnished by the brake company to be used in the repairs, and do not include the cost of taking off the old and putting on the new. A statement furnished me by the company of the cost of materials delivered to the St. Louis and San Francisco Railroad Co. for the repairs of 100 stock cars, Nos. 3600 to 3699, from the period when they went into service, which was May 27th to June 10th, 1884, up to July 1st, 1885, an average period of about 13 months, shows the total cost of the materials to have been $49.43, an average of less than 50 cents per car. The mileage of several of the cars shows them to have run from 12 700 to 18 300 miles each during the period. Taking interest on cost at 6 per cent., and on the basis of brakes being applied to both trucks of each car, the annual charge against each car for the use of brakes would be approximately as follows:

Westinghouse Automatic.		American Automatic.	
Interest, say	$3.40	Interest	$1.70
Maintenance	2.27	Maintenance	.50
Total	$5.67	Total	$2.20

Either of these sums is wholly inconsiderable compared with the saving made by the use of the brakes, which is to be calculated not only upon the amounts saved by lessening the damage in wrecks, but allowance should also be made for the saving in flattened wheels and other items of general repair, and it is especially suggested that the danger to human life involved in the present system, the risks run by employees, and by drovers and other persons who are allowed to ride upon freight trains, cannot be justified when they can be so greatly reduced at what is shown to be so trifling a cost. The great reduction in the cost of freight cars, combined as it is with the increase in their capacity, certainly warrants the railroad companies in introducing this improvement, particularly as it is easily demonstrable that the annual saving will amount to a very high percentage upon their cost.

The Westinghouse automatic brake has been proved in innumerable instances to be exactly adapted to the wants of the passenger train

service. In the general remarks of the committee of the Master Car Builders' Association, the following expression occurs: "If compression brakes are equal to or better than air brakes, why don't their advocates undertake to fit up our passenger equipment with them?" After some further discussion the committee states:

"The reason compression brakes are not applied to passenger equipment is because they do not fulfill the requirements of the service as well as air brakes. They are not automatic in every respect as the air brake is; a conductor or brakeman on any part of the train cannot at a moment's notice apply the brake on every car and engine; in case the train parts while running, the brakes are not instantaneously applied to every wheel in both sections of the train.

"This, together with other features, might be cited as making the air brake indispensable for passenger service. Are not these same points desirable for the success of an automatic freight-car brake? Your Committee think they are beyond any doubt desirable, but how to accomplish it is not so clear."

The use of the word "automatic" in the sentence above quoted, is not warranted by the proper definition of that word. The context following the expression "They are not automatic in every respect as the air brake is," while probably not so intended, conveys the idea that an automatic brake is one which the conductor or brakeman can at a moment's notice apply, etc. Webster defines the word automatic as "Relating to an automaton; operations carried on by self-acting machinery." The application of the word to brakes can only be proper when used to convey the idea that the brake is self-acting. A brake which is put in action by the engineer opening a valve, or by the conductor or brakeman pulling a cord, is not self-acting, and is therefore not automatic.

Tested by this rule, the Westinghouse brake is automatic when the train parts while running; it is not, so far as the writer understands the matter, automatic under any other conditions of its use, but as that is the condition which was specially intended to be met by the brake, the designation automatic is proper, as indicating the difference between that form of air brake and that which is known as "non-automatic or straight air."

The Car Builders' Committee, in using the expression "They are not automatic in every respect as the air brake is," certainly failed to comprehend the real meaning of the term. I have thought it important to discuss this matter at some length, because great stress is laid by all parties upon the necessity of having automatic brakes, while the question as to what an automatic brake is, or when a brake is automatic, is not

dwelt upon. The American Brake Company styles its freight-car brake automatic. It does not apply itself or is not self-acting when the train parts, and in that particular it is inferior to the Westinghouse brake, but it is automatic in that it does apply itself or is self-acting under several other conditions, such as:

First.—When steam is shut off upon the engine the brake is brought into action in a slight degree, as shown by the short wave at the beginning of the strain diagrams, producing a little pressure on each wheel, which steadies the train. When the engine is reversed the brake is applied effectually.

Second.—When the engine is derailed or meets an obstruction, all the brakes are applied automatically, with force in proportion to the momentum of the train and the character of the obstruction. This feature, I am informed, has proved of great value on the St. Louis and San Francisco Railroad, in one case saving a train from wreck by running into a land slide.

Third.—In case any car of the train is derailed, the brakes on all the cars of the train in the rear of the derailed car are applied automatically. This is not the case with the Westinghouse brake, unless the derailment separates the train into two parts, or in some other manner breaks the air-pipe or its connections so as to permit the escape of air.

I do not consider the application of brakes caused by the engineer putting on the driver and tender brake as an automatic application, as in that case his action is analogous to that of the engineer opening the air-valve of the Westinghouse brake.

In the ordinary application of the brakes by the engineer, both brakes are non-automatic in their action.

The manner in which the importance is urged of having a freight-car brake that will be automatic in case the train is parted, suggests that to arrive at a correct judgment on this point an inquiry is necessary to determine the proportion that such occurrences bear to the accidents of other character requiring a prompt application of the brakes. I have procured from the files of the *Railroad Gazette* a statement of the number of accidents to trains on railroads of the United States during the years 1873 to 1884, inclusive, which follows as Schedule No. 11.

SCHEDULE No. 11.

Number of Accidents to Trains on Railroads of the United States during the years 1873 to 1884, inclusive, as reported by the *Railroad Gazette*.

Character of Accidents.	Years.												Total.	Average.
	1873	1874	1875	1876	1877	1878	1879	1880	1881	1882	1883	1884	12 Years	Per Year.
Collisions—														
Rear	187	131	141	159	159	142	206	274	306	388	413	280	2 786	232
Butting	102	87	104	94	96	70	86	141	146	160	177	138	1 401	117
Crossing	31	19	18	15	13	7	17	22	24	30	39	27	262	22
Passing	..	..	..	..	..	..	..	..	..	3	..	..	3	....
Unexplained	72	23	15	11	..	1	1	..	..	..	..	..	123	10
Totals	392	260	278	279	268	220	310	437	576	581	629	445	4 575	381
Derailments—														
Defects of road	167	129	206	125	118	72	94	89	169	156	227	182	1 734	144
Defects of equipment	73	63	100	76	66	41	66	64	124	102	129	67	971	81
Negligence in operating	101	93	100	108	85	65	90	98	104	101	112	94	1 151	96
Obstructions	152	141	207	160	131	125	113	108	150	144	199	152	1 782	149
Unexplained	322	228	227	186	181	178	194	238	310	239	259	186	2 748	229
Totals	815	654	840	655	581	481	557	597	857	742	926	681	8 386	699
Other causes—														
In which stop is important	57	46	54	26	27	27	25	27	50	27	66	47	479	40
Explosions	19	20	29	22	15	12	18	17	15	15	18	18	218	18
Totals	76	66	83	48	42	39	43	44	65	42	84	65	697	58
Grand totals	1283	980	1201	982	891	740	910	1078	1498	1365	1639	1191	13 658	1 138

SUMMARY OF ACCIDENTS IN 1884.

	Collisions.	Other Kinds.	Totals.
Passenger Trains	48	284	332
Passenger and Freight	122	....	122
Freight Trains	275	462	737
Totals	445	746	1 191
Total Freight Trains	397	462	859
Trains parted	43	....	43
Per cent	11		5

This shows that the average number of train accidents reported for the twelve years was 1 138 per year; while the summary of accidents in 1884 shows 1 191 in that year, being a very close approximation to the twelve years' average. By a careful examination of the monthly reports of accidents printed in the files of the *Gazette*, I learned that the number reported as caused by trains parting during 1884 was 43; while the number of accidents in which freight trains were involved were: collisions, 397; other accidents, 462; total, 859; so that the proportion which the accidents caused by trains parting bear to the number of collisions was 11 per cent., and its proportion to the whole number of accidents to freight trains was 5 per cent. It does not seem, therefore, that the provision for stopping the detached section in the case of breaking of trains is of such importance that other conditions should be subordinated to it. It may further be of value to inquire into the causes of this class of accidents with a view to their possible prevention. When a freight train breaks in two it is usually at the bottom of a down grade, and most frequently where a down grade and an up grade meet, forming a synclinal. With a train equipped with hand brakes, when coming down a grade the brake is usually set on the caboose, and perhaps on one or two of the rear cars, by the conductor or brakeman, and on the tender by the fireman. Upon reaching the bottom of the grade the fireman promptly lets off the tender brake while the engineer gives his engine steam, pulling out sharply as the up grade is reached, thus taking up the slack of the train as fast as the cars reach the bottom of the grade. This operation of taking up the slack results in a series of jerks which, in a long train, is met by the resistance offered by the rear cars having their brakes on, and occasionally results in breaking a coupling. The experience of the American brake on the St. Louis and San Francisco Railroad shows that the buffer brake prevents this action, as in its use the brakes are on all the cars lightly while coming down the grade, and are taken off as rapidly as the cars reach the foot of the grade, and the slack is taken out while there is a slight resistance in the rear, because the brakes are set lightly on all the cars, instead of being set firmly on the last two or three. The St. Louis and San Francisco road is a surface road, having a great many of these "sags," as they are called, causing a great liability to trains breaking in two. The Vice-President of the road informed me that the number of such accidents since the American brakes had been applied was greatly decreased.

As prevention is better than cure, this seems to be a strong argument in favor of the buffer brake.

The Master Car Builders' Committee state, as their opinion, that the points referred to as making the air brake indispensable for passenger service are beyond any doubt desirable for the freight service, but the Committee does not refer to certain conditions of the freight service which do not exist in the passenger service, and which are equally important to be taken into account. The question of the initial expense to which they do refer in a brief way is a very important one. There are in the United States, approximately, 25 000 engines and 900 000 freight cars. Of the engines about 12 000 are already equipped with the driver brakes, leaving 13 000 to be equipped. The initial cost furnished by the two companies for equipping the entire freight equipment of the roads by the two systems with double brakes would be as follows:

WESTINGHOUSE SYSTEM.

13 000 engines at $500	$6 500 000
900 000 freight cars at $56.50	50 850 000
Total	$57 350 000

AMERICAN SYSTEM.

13 000 engines at $225 each	$2 925 000
900 000 freight cars at $28 each	25 200 000
Total	$28 125 000

The cost of the latter being in round numbers about one-half the cost of the former system. The further comparison of the two systems involves a consideration of certain questions which arise in the freight service, but are not met with in the passenger service. Taking all the railroads of the country, probably at least 90 per cent. of the passenger trains are made up wholly of cars belonging to the company owning the road, and therefore if its cars are equipped with a power brake all the cars of every train will have that brake. The exceptions to this condition are of two kinds: when two or more roads are so operated together as to form a line and interchange their passenger cars, and when two or more roads form a line for running sleeping or parlor cars. In these cases if the roads forming the line adopt the same brake, the

result is reached of having all the cars of every train equipped with that brake. The mere difference in number between the passenger cars and the freight cars makes a great difference in the conditions.

Freight trains, on the contrary, are made up of cars from an indefinite number of roads, many of which do not connect with, or reach within hundreds of miles of the road upon which the trains are being run. A train of forty cars will very frequently contain twenty or thirty varieties as to their ownership. I recently noticed on the Pennsylvania Railroad a freight train of 34 cars which contained but *one* Penna. Railroad car. In the use of a continuous brake, it is essential to the operation of the brake on each car that it be connected with the engine. If all the cars but one of a forty-car train be equipped with such a brake, the brakes on all the cars in the rear of that one will be inoperative. The reasons governing the shifting of cars, their location in the trains with reference to their destination, preclude the idea that trains can be made up with reference to the kind of brakes they may have so as to bring all the cars having the continuous brake into connection with the engine. For these reasons, the following are believed by the writer to be essential conditions to the successful general adoption of a freight-car brake:

1st. It must be a detached brake.

2d. It should be as automatic as possible; that is, under as many conditions as possible.

3d. It should require no application of the hand at each car by turning a lever or pulling a cord, to set it in action or to release it after action; nor would a brake be satisfactory that requires reversing in order to make it apply when the cars are running in opposite directions.

4th. It should be prompt in action.

5th. It must be prompt in releasing when the train comes to a stop.

6th. It must not slide the wheels, as flattened wheels are a serious cause of expense.

7th. It should come into action without regard to the position in the train of the car or cars to which it is applied.

8th. It should act when necessary without the volition of the engineer; so that, when the cars to which it is applied are on a foreign road, it will be applied by the ordinary action of the engineer, whether or not he knows of its presence in the train.

9th. It should be simple in construction, reasonable in cost and economical in maintenance.

The American brake meets these conditions far better than I had reason to believe prior to making the tests of which this paper is a report. Before undertaking this investigation I was not favorably inclined to a buffer brake, as I did not think it would prove of sufficient value in practice to warrant its general adoption. These tests have satisfied me that a properly constructed buffer brake is a great addition to the freight equipment of a railroad.

While in using this form of brake the strain on the pull-rod, and the consequent pressure on the brakes, remains measurably constant to the end of the stop, the evidence shows that it does not slide the wheels. The train with which my test stops were made, when it reached St. Louis after a ten weeks' trip, making several hundred special test stops, had not, I am informed, a single flat wheel.

The Vice-President of the St. Louis and San Francisco Railway states that the brakes do not get out of order when the cars are off on foreign roads, which is an important consideration.

In conclusion, I am impressed with the value of the Westinghouse automatic brake for roads having grades approximating two (2) per cent. (105.6 feet per mile) and upwards, and particularly where, by reason of the gauge or location they run their own cars exclusively, or nearly so; but I cannot think that any continuous brake can come into general use, for the reasons:

1st. Its high cost, compared with that of a good buffer brake.

2d. The necessity of having a large proportion of the freight cars of the country equipped before much advantage can be had from its use.

3d. Because a good buffer brake can be had at half the cost, and which, being detached, will do its share of the braking wherever the car or cars may be placed.

The maximum gradients on a very large proportion of the railroads of the United States—probably on three-fourths—do not exceed 52.8 feet per mile.

My experiments with the American brake, on this gradient, descending, show that by its use a train of 400 tons, running 25 miles per hour, can be stopped in 41 seconds in running 839 feet, while, with 3 brakemen setting hand brakes it took 95 seconds and 2 322 feet. With a long and heavy train the disparity would be still greater.

The evidence shows that a good buffer brake is a valuable addition to the driver-brake for stopping freight trains, and that the American brake

is cheap in cost, economical in its maintenance and reasonably efficient in its action. By its use many times its annual cost will be saved to the companies adopting it, and many lives will be saved every year. I fully believe that the saving in current expenses, by dispensing with brakemen, avoiding flattening of wheels, time saved in switching and handling trains at stations and sidings, etc., will more than pay its annual cost, leaving the saving in expense of accidents and wrecks as entirely a profit by its use.

While I have agreed with the Westinghouse Company in recommending the use of brakes on both trucks, or "double" brakes, the tests show that great advantage over hand brakes is attained by having "single" brakes on the cars, with the "driver and tender" brake, and to such railroad companies as feel unable to incur the expense of double brakes, I say unhesitatingly, provide your freight engines at once with driver and tender brakes, and your cars as soon as practicable with single brakes, to be followed by double brakes when you can afford the additional investment.

Thus I think it has been demonstrated that there is great need for "power brakes for freight trains," and that their adoption will be a measure of true economy in railway management.